SCIENTIFIC AMERICAN SUPPLEMENT. No. 1544

Entered at the Post Office of New York, N. Y., as Second Class Matter. Copyright, 1905, by Munn & Co.

Scientific American, established 1845.
Scientific American Supplement, Vol. LX., No. 1544. NEW YORK, AUGUST 5, 1905. Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE NEW AND THE OLD: A RACE BETWEEN THE ELECTRIC AND STEAM LOCOMOTIVES OF THE NEW YORK CENTRAL AND HUDSON RIVER RAILROAD, BOTH THE LATEST TYPES.

COMPARATIVE TESTS OF STEAM AND ELECTRIC LOCOMOTIVES.

IN our issue of February 18 of this year will be found an illustrated article describing the six-mile stretch of experimental track upon which the New York Central Railroad Company is carrying on very exhaustive tests of its new electric equipment. This locomotive is the first of a large order, and it is the type to which will be intrusted the important work of handling the express-train service running into and out of New York city. The tests were carried on day by day, throughout the whole of the winter and spring under every condition of weather. On April 29 last, it was decided to carry through a series of comparative tests between the new electric locomotive and the newest and most powerful express locomotive that is now handling the New York Central trains. There were two sets of tests, one with an eight-car and one with a six-car train. The steam locomotive, which is a truly enormous engine, has 22 x 26-inch cylinders, 3,757 square feet of heating surface, and weighs with its tender, 342,000 pounds. In the first test it was placed on the express tracks, opposite the point at which the electrically-equipped local stretch of track begins, with eight or six passenger cars behind it. The electric locomotive, which weighs 200,500 pounds, was placed on the electric tracks with the same number of cars behind it, and these cars were loaded so as to bring up the total weight of engine and train to that of the steam train with its engine. Consequently, the electric locomotive was hauling, in the case of the eight-car train, a load greater than that hauled by the steam locomotive by 70.75 tons. This fact should be borne carefully in mind if we would appreciate the great superiority shown by the electric locomotive. In every test the two trains started from rest, and careful records were made of the speed, distance, time, and power consumption. The trials were witnessed by Mr. W. J. Wilgus, vice-president, and Mr. E. B. Kettee, electrical engineer of the New York Central Railroad Company, and by Mr. E. W. Rice and other officers of the General Electric Company, the builders of the engine.

TIME OF TEST AND WEATHER CONDITIONS.—The test started about 8 A. M. and continued until about 1 P. M. of April 29, 1905; temperature averaging about 50 deg. Fahr., cloudy. During the time of the test no rain fell, so that the rails were perfectly dry.

DESCRIPTION OF EXPERIMENTAL TRACK.—The experimental track, six miles in length, is the portion of old track No. 4, formerly used for east-bound freight movements between mile-posts 162 and 168 west of Schenectady. The working conductor consists of top-contact 70-pound steel rail reinforced with copper, and covered in part with a board protection. The alignment and grades on the six-mile stretch of track ("race track" for the time being) are easy. From the easterly end of the track at mile-post 162, going westerly, the rising gradients vary from 5 feet to 17 feet per mile to a summit between mile-posts 166 and 167, and thence the track descends on gradients varying from 6 to 19 feet per mile to the end of the track at mile-post 168. In the six miles there are seven curves varying from 0 deg. 48 min. to 20 deg. 17 min., the maximum length of tangent being 7,565 feet.

SOURCE OF POWER, TRANSMISSION LINE AND SUB-STATION.—The power for testing purposes is furnished by the General Electric Company, and for this purpose there has been installed at their Schenectady plant a 2,000-kilowatt three-phase 25-cycle Curtis turbo-generator, delivering 11,000 volts to the line. A special high-tension transmission line has been constructed for the intervening distance of about five miles to a sub-station that has been erected by the railroad company near mile-post 165. This sub-station contains a 1,500-kilowatt, 650-volt rotary converter, with static transformers for reducing the potential from 11,000 volts to 475 volts.

DIMENSIONS AND WEIGHTS OF THE TEST TRAINS.—The weights of the cars and locomotives were as follows:

EIGHT-CAR TRAIN.

Electric Train.			Steam Train.		
No.	Car No.	Weight Loaded.	No.	Car No.	Weight No Load.
1	1060	101,900	1	2527	79,900
2	1070	100,400	2	1547	86,100
3	1062	100,200	3	1534	87,800
4	1042	104,100	4	1521	84,500
5	1097	104,650	5	1069	86,300
6	1550	102,800	6	1090	87,400
7	1552	100,000	7	1503	86,400
8	1558	104,750	8	1513	86 700
	Locomo.	200,500		Locomo.	342,000
	Total,	513.6 tons		Total,	513 tons

SIX-CAR TRAIN.

Electric Train.			Steam Train.		
No.	Car No.	Weight Loaded.	No.	Car No.	Weight No Load.
1	1060	101,900	1	2527	79,900
2	10.0	100,400	2	1547	86,100
3	1062	100,100	3	1534	87,800
4	1097	104,650	4	1521	84,500
5	1550	102,800	5	1069	86,300
6	1558	104,750	6	1.90	87,400
	Locomo.	200,500		Locomo.	342,000
	Total,	407.5 tons		Total,	427 tons

It will be noted that, due to the restricted cross-section of conductors, the voltage dropped during acceleration considerably lower than will obtain in actual practice within the electric zone in the neighborhood of New York. Therefore the results obtained in this comparative test are much less favorable for the electric locomotive than will be secured in actual practice.

AVERAGE VOLTAGE DURING ACCELERATION.

Runs.	Series.	Series-Multiple.	Multiple.
A	520	540	325
B	620	520	275
C	600	540	330
D	680	680	515
E	650	600	420
F	600	620	455

RUN "A."—The "Pacific" type steam locomotive had an eight-car train, with a total weight, including the locomotive, of 513 tons, as compared with the eight-car train behind the electric locomotive weighing 513.6 tons. Both trains started together, with the steam locomotive accelerating faster than the electric locomotive, due to the abnormal drop in voltage from the pressure at the station of 700 volts to a track voltage as low as 325 volts. At 3,000 feet from the starting point the electric locomotive gained the same speed as the steam locomotive, and from that point accelerated more rapidly, so that at a distance of two miles from the starting point the electric locomotive passed the steam locomotive, and at the shutting-off point was two train lengths ahead. The maximum speed of the steam locomotive was 50 miles per hour. The maximum speed of the electric locomotive was 57 miles per hour.

RUN "B."—This run was made under the same conditions as run "A," with results practically the same, except that the speeds were higher, as follows: Maximum speed of steam locomotive, 53.6 miles per hour; maximum speed of electric locomotive, 60 miles per hour.

RUN "C."—This run was made with six-car train for both locomotives, with total train weights as follows: Electric locomotive, 407.5 tons; steam locomotive, 427 tons. Owing to extreme low voltage under the conditions above stated, which during acceleration fell as low as 330 volts, at first the steam locomotive accelerated more rapidly, but at the end of about a mile the electric locomotive overtook the steam train, and continued to forge ahead until the power was shut off. Maximum speed of electric locomotive, 61.6 miles per hour; maximum speed of steam locomotive, 56 miles per hour.

RUN "D."—In order to secure as nearly as possible results comparable with the conditions of voltage that will obtain in the actual operating zone, this run with six-car trains, similar to those used in run "C," was started at a point nearer the sub-station, near mile-post 164. For this run the electric locomotive from the first turn of the wheels accelerated faster than the steam locomotive, as plainly illustrated in the attached photograph, our frontispiece, and, at a distance of 1,500 feet from the starting point, the electric locomotive led by a train length.

RUN "E."—This run was made with the electric locomotive and one coach, a maximum speed of 79 miles per hour having been attained.

RUN "F."—This run was made with the electric locomotive running light and with the power shut off on curves, a maximum speed having been attained of 80.2 miles per hour.

Had it not been necessary to shut off the current on curves, it is believed that the locomotive would have attained a speed of over 90 miles per hour in this comparatively short run.*

SUMMARY OF RESULTS.—The most important test is run "D," as the voltage during that test more nearly approached the conditions that will be obtained in the electric zone. Therefore, the following comparison of the steam and electric locomotives based upon the results of run "D" are very interesting as illustrating the marked superiority in acceleration of the electric locomotive over the steam locomotive, considering the fact that the "Pacific" type of steam locomotive has practically the same weight upon the drivers.

CONDITION IN RUN "D."

	Steam.	Electric.	Difference in favor of Electric.
Length over all.....	67 ft. 7¾ in.	36 ft. 1.¼ in.	30 ft. 8½ in.
Total weight (inc. tender for steam locomotive).	342,000 lb.	200,500 lb.	141,500 lb.
Concentrated weight on each driving axle.....	47,000 lb.	35,500 lb.	11,500 lb.
Revenue-bearing load back of locomotive.....	256 tons.	307.25 tons.	51.25 tons.
Acceleration miles per hour per second average up to 50 M. P. H.....	0.246	0.394	0.148
Time required to reach speed of 50 M. P. H.....	206 sec.	127 sec.	76 sec.

* A speed test on May 1 reached 85 miles per hour with a limitation on the 2 deg. 17 min. curve of 78 miles per hour.

PROPER METHODS IN CONDUCTING PAINTING TESTS.†

A NUMBER of years ago the president of our Society, Dr. Dudley, wrote a series of papers treating of the characteristics of paint and, we believe, for the first time in the history of the art, attempting some scientific understanding of paint problems. Not merely were these papers the first, in our opinion, that treated of the subject of paints scientifically, but it may be said that since that time practically no progress has been made along this line. It is to be deeply regretted that Dr. Dudley has not had time to enlighten the public further in this direction; for we are confident, had he been able to do so, the science of painting and paint manufacture would have been very much simplified. The situation, as it is presented to-day, is this: New paint materials are offered to the consumer from time to time, these paint materials having more or less value, but in regard to which the manufacturers, as a rule, claim a somewhat more universal merit than these paints in actual use would warrant. It is natural for the paint manufacturer to advocate the use of his product or products for every condition under the sun, because he hopes by this broad advocacy to increase their sale. If there is one principle, however, on which the members of this Society are pretty well agreed, it is that there is no complete paint which is suitable for all conditions of exposure; that is, every paint must, at least, have its various components put together in different proportions, according to the conditions of exposure to which it is to be subjected.

We believe that it is the business of the engineer to design the paint which he is going to use under any given conditions. We believe that the paint manufacturers are only too anxious to supply what the engineer may demand. If the engineer starts out to select a paint, his proper attitude is not to take any one of the prepared paints on the market and specify that because the manufacturer tells him it is the best for the purpose in question; but it is his duty to make such experiments as are practical for the purpose of finding out what paint is best for the conditions to which the paint surface is to be exposed. To examine a paint on a large scale is, of course, the most satisfactory way, provided the paint turns out well. We are unquestionably of the opinion that the surest proof of a paint is its use, just as we are confident that the best way to detect a poison is to take it internally. The unfortunate part of the matter is, however, that the use of paint in order to find its value may leave the user firmly convinced that this value is a negative quantity. Supposing that he is able to try a paint in a limited way on full-size structures, and the result, while not a minus result, is really very near that—that is to say, suppose the result leaves him somewhat in doubt—how is he going to tell whether the fault lay in the paint or its method of application? How can he be sure that the relative failure of the paint may not have been due to inherent destructive conditions external to the paint itself, but peculiar to the structure painted? A painting test of this kind, properly called a "field test," is of inestimable value when accompanied by tests conducted under conditions all of which are known. These are what may be called "laboratory tests," and, if conducted with care and parallel to field tests, they act as a check upon the results obtained by these field tests and give a better basis on which to rest scientific conclusions. These laboratory painting tests, made with the intent of exposure under service conditions, should be supplemented by other laboratory tests which should parallel information enabling the engineer or paint chemist to determine the relative value of a given paint in advance of the results which are obtained by field or laboratory tests under service conditions. We must not reverse this order, however, and attempt to substitute purely chemical tests for exposure tests under service conditions until the laboratory tests have demonstrated their value.

By the term "painting tests" in our title we have intended to include those tests which can be conducted with scientific accuracy, but which at the same time are as close as possible to ordinary practice so long as this accuracy is not impaired. Unfortunately, tests supposedly of this kind are in most cases without value. So much is this the case that laboratory painting tests are often spoken of in words of derision, as though they could be made to produce any result desired by the skillful manipulator of the brush. In most cases, these painting tests are made by persons interested in exploiting certain products, whereas they should be conducted principally by the consumer. The primary cause for the lack of value which these painting tests usually show is that they are not conducted with sufficient accuracy. Tests of this kind should be conducted under the supervision of a competent engineer or chemist and with as much care as if a chemical analysis were being made.

Committee E, of the Society, has outlined a method of conducting painting tests for protective coatings, this method demanding proper attention to all those details which are essential to the attainment of accurate results. These tests, when carried out by the sub-committee having them in charge, should prove of inestimable value. There are other paints, however, which, though "protective," are used for the purpose of producing a desired finish of appearance. Most paints are of this kind, and I propose, with your permission, to say a few words about painting tests made, using this class of paints.

Let us, to start with, take the question of the relative "covering power" of paints. To my mind, the term "covering power" has only one proper meaning, that is, the power to hide the surface painted. It is, as Dr. Dudley has pointed out, a function, first, of the light-destroying or absorbing power of the constituents of a paint, and, second, of the difference in refractive index between the pigment and vehicle. Whatever it may be caused by; however, we are more interested in the actual facts of the case than in the reasons therefor. In comparing two paints for covering power, it is generally understood that these two paints should have practically the same color and be very nearly alike in tone, for the eye is not able to note accurately the difference in covering which exists between paints of different colors or tones. When we compare two paints of the same color and tone for covering power our work is somewhat simplified when it is borne in mind that very few paints are homogeneous as regards pigment. Most paints contain several pigments, the principal one being a white pigment of some kind. Only with straight white or dark colors is the pigment like-

† A paper read before the American Society for Testing Materials by Gustave W. Thompson.

ty to be homogeneous. Furthermore, with the colored paints consisting largely of white pigment, the tinting material is so fine that only a very small amount is usually needed to give the tint desired. In this case, the actual covering power of the paint is principally dependent upon the white pigment present. Our greatest interest, therefore, centers around the covering power of white paints; for, when we wish to design a paint of a certain color, we usually select a given white paint and add to it such coloring materials as have the highest possible tinting power and of which consequently we have to add the least amount possible. The result is that, practically speaking, tests for covering power are demanded for white paints only, and it is of these that I desire to speak.

On the threshold of our inquiry we are confronted by two difficulties. The first of these has to do with the amount of vehicle we are to use to get the "consistency proper for painting." In the present state of the art there is apparently no method for determining this consistency; the consistency proper for painting is simply a matter of rule of thumb. There is nothing standard about this consistency; it may be one thing in winter, another in summer; one thing with a flat brush, another with a round brush, and still another with the squirt gun. We have a refuge, however, and that it seems to me, is the only safe one. When we have mixed our paint to a "consistency proper," in our opinion, "for painting," let us record the formula on which we prepared the paint and let our report state this formula in full detail. If the paint was a prepared or ready-mixed paint, then the analysis of the paint should also be reported in as nearly formula form as possible. In other words, we may have difficulty in determining what is the consistency proper for painting, but we need have no difficulty in recording the composition of the mixture which was used in making a given test for covering power, and this, in the present state of the art, is all that we can ask.

The second difficulty which presents itself is in the adoption of a spreading rate per gallon of paint. There can in practice, of course, be no standard spreading rate, and yet we have found that any white paint which has, according to our experience, a consistency proper for painting can be readily brushed out so as to cover 1,200 square feet to the gallon of paint when applied to a fairly smooth surface, and in most cases, if it is not spread out at that rate, the paint will run. We solve this difficulty of the spreading rate at which the paint is to be applied in the same way that we solve the difficulty in connection with the consistency proper for painting; that is, we simply make the spreading rate followed a matter of record.

To illustrate, let us suppose that we have received two paints which we desire to compare for covering power: these paints, we will say, are prepared paints—that is, they have been thinned to a "consistency proper," in the manufacturer's opinion, "for general painting." We would, first of all, analyze these paints to determine the formula on which they were prepared. Inasmuch as the pigments in the two paints may vary in composition and, consequently, in specific gravity, we make a determination of the weight per gallon of paint as received, and, knowing the percentage by weight of the vehicle present, we calculate the percentages by volume of vehicle and pigment present, which gives us a somewhat better conception as to the nature of the paints. All the information we have thus obtained is recorded. Our next step would be to compare these two paints as to the relative ease with which they can be spread over the same area, without any particular regard to their covering power. If we find that they can be spread over the same amount of surface without, as is usual, great difficulty, we adopt a standard spreading rate for the two paints—say, 1,200 square feet to the gallon, one coat—and apply the paints to standard prepared surfaces at that rate, and when we are through we compare the paints for their covering power or power to hide the surfaces painted. Now let us compare this method of making a painting test for the covering power of white paints with the method usually followed. Jones has a paint that he wants tested. He takes it to his friend Brown, the painter, and wants his opinion. Brown reports in a few days that the paint he received from Jones covered better than any paint he had ever used. Now, Brown may have been perfectly honest in making this report to Jones, but unless the formula on which the paint was mixed and the rate at which it was spread is given, Brown's opinion is worse than useless.

We describe here more in detail our method of comparing white paints for covering power: Use white pine boards, 30 inches long by 10 inches wide and approximately 1 inch thick. Each end of the board is provided with a cleat having a tongue fitting into a groove on the end of the board and securely nailed on. The entire board, including the cleats, is to be finished to the size given above. Three of these boards are primed with, we will say, the following paint mixture: White lead paste, 100 pounds; linseed oil, one-third boiled, 75 pounds. No attempt is made to secure a definite amount of priming paint to the unit of surface; this for the reason that the boards may vary considerably in their absorptive power. When this priming coat is dry each board receives a diagonal stripe of lampblack in japan about 1 inch wide on one or both sides of the board, as may be desired. When this black stripe is dry it is given a second coat of paint mixed to a consistency proper for painting, the formula being recorded. The weight per gallon of the paint so mixed is then obtained by finding its specific gravity and multiplying by 8.33, which gives the weight per gallon. Inasmuch as the board which we are using has a total surface of 680 square inches, all we have to do is to find what the ratio is between 680 square inches and the spreading rate at which we desire to apply the paint in order to find the fraction of the gallon which we wish to apply to each board. If the rate adopted is 1,200 square feet to the gallon, then we get the formula: 680 square inches : 1,200 square feet :: 1 : x, the reciprocal of x being the fraction of a gallon of paint to be applied to each board, one coat. Having the weight of the paint per gallon, we easily get the amount of paint by weight to apply to each board, one coat on all sides. When this second coat of paint is thoroughly dry a similar coat is applied, and when dry the boards can be compared for the covering power of the paints on them. We mention the painting of three boards with each paint to be compared; the purpose of this is that variations in results are obtained between boards which are apparently painted in an identical manner. These variations are not great, but it is thought best to eliminate them, to a certain extent, by painting three boards and selecting the one giving medium results for comparison with boards painted with other paints.

Tests conducted along these lines, we believe, will give valuable and scientific results and will enable the intelligent person to draw safe conclusions.

Let me state here, by way of illustration of the usefulness of this method, one of the results obtained by tests comparing pure white lead and linseed oil with a mixture of white lead and a small amount of barytes with linseed oil. The pure white lead was mixed on the formula of 100 pounds of white lead paste to 30 pounds of linseed oil. Two mixtures containing barytes were made on the same formula as the white lead and pure linseed oil, except that to the pure white lead was added an amount of barytes corresponding to 10 per cent by volume of the white lead present, and the amount of oil was also increased 10 per cent, so that the mixed paint contained in each case the same percentage of pigment by volume and the same amount of oil by volume. Another mixture was made, adding 20 per cent by volume of barytes to the sample of white lead paint and a corresponding amount of oil. These three paints were then compared by the above method for covering power and spread at the uniform rate of 1,200 square feet to the gallon. The result was that both paints containing barytes showed a very perceptible diminution in covering power. Now, this illustration has not for its purpose the saying of anything in favor of white lead and against barytes, but simply to show that if the statement is made that a small percentage of barytes can be added to white lead without impairing its covering power some explanation must be made as to the method by which such a result is obtained. If in any painter's hands the result has been found that the addition of a small percentage of barytes did not impair the covering power of the white lead, it must have been due either to the fact that less oil was used or that less surface was covered per gallon of the paint containing barytes than by the straight white lead.

Perhaps the most important test that can be applied to paints is a durability test; that is, a test as to the permanency of the paint film itself. Boards painted, as in the making of the covering power tests described above, can be exposed to the weather and the durability of the paint films observed. Durability tests, to be of value, should be conducted with the same care as the covering power tests. The formulas on which the paints were mixed should be recorded, also the rate per gallon at which they were spread.

Quite recently painting tests with a view to observing the durability of various paints were reported on to the International Association of Master Painters and Decorators, and the results obtained were published generally in the paint journals. Undoubtedly, these tests were conducted conscientiously and the conclusions reported give honest opinions about the results obtained. We feel, however, compelled to question these results for several reasons which appear very important. In the first place, single boards only were painted with each paint and exposed. At least three boards should have been painted and exposed alongside of each other, and the board which showed results about the average of the three should have been selected for comparison with other paints similarly selected. Very frequently it will be found that two boards painted apparently in the same manner and with the same paint will show differences in results due to differences in the boards themselves. In the second place, the formulas on which the paints were mixed are not stated with sufficient detail. In the third place, there is no information given as to the spreading rate at which the respective paints were applied. Considering any two of the boards, the paint on one board may have been twice as thick as on the other, for all we know to the contrary. We have very little doubt that the thicker the paint film, the greater its durability. This emphasizes the importance of having painting tests conducted under the supervision of the engineer or chemist. The ordinary master painter is, we believe, thoroughly competent to interpret results and to conduct field tests on full-size structures, but when it comes to preparing boards for exposure special training is required, such as the chemist or engineer only can be said to have.

To conclude, no matter what the painting test may be, whether it be of colored paints or white paints, whether it be with homogeneous or mixed pigments, whether it be for covering power or durability, the essential features that we should insist upon are that the formula of the paint should be stated fully; that the thickness of the film, or what is the same thing, the rate at which the paint is spread, should also be stated. These two requisites of proper painting tests should also be demanded in all tests for the permeability of paint films or their permanency, no matter how these tests may be applied. If we wish to compare two paint films for their permeability by the dextrine test, we should know, to start with, that these two films have approximately the same thickness. It is a safe assumption that the thicker the paint film, the less its permeability. If we desire to compare two paint films for their permanency, we should know that these two paint films are of the same thickness, as the elasticity and general life of the film are proportionate to its power of resistance to oxidizing influences, and the thicker the film, the more permanent are its inner parts.

ELECTROTYPING.*

By DR. F. MOLLWO PERKIN.

GENERALLY speaking, the original is first formed in plaster of Paris. The plaster cast is then thoroughly saturated with boiled linseed oil or with melted paraffin wax. After standing for some time to allow the oil or wax to thoroughly set and harden, the entire surface is brushed over with graphite, and is then polished, so as to form a homogeneous conducting surface.

The model so prepared has conducting wires fixed against different portions of the surface, so that the electric current may be evenly distributed, and is then connected with the negative pole of the source of current and placed in a copper sulphate bath. When a coating of sufficient thickness has been obtained—about 1-16 or more of an inch—the figure is removed from the bath and carefully washed. It is now necessary to remove the plaster form, and this is done by cutting the deposited copper in appropriate parts, so that the copper shell can be removed in portions. The fewer cuts that require to be made, the better, so that the portions of shell may be as large as possible.

The parts or "formes" of the copper shell so obtained represent the negatives or molds upon which the positive is to be deposited. The inner portion of the formes are exposed to the fumes of sulphureted hydrogen or are washed with a dilute solution of potassium sulphide. By this means the copper becomes coated with a thin film of copper sulphide, which is conducting, but upon which the copper to be deposited will not adhere. The outer surfaces of the mold are varnished to render them non-conducting. The various portions of the shell are then placed in a coppering bath and the current passed. When the deposited copper reaches a thickness of about one-seventh of an inch, they are removed from the bath and well washed. The freshly-deposited shell is now carefully stripped off from the outer shell and the different parts joined together.

Stereotyping.—The most important application of electrotyping is in the preparation of stereotypes. When a large number of copies of a book require to be run off, and in order not to keep too large a quantity of type set up, a copy is reproduced in stereotype. The following description of the procedure adopted is the principle of the process, although individual firms adopt methods which vary in detail. Suppose it is required to produce a stereotype of a page of a book. The set-up type is placed face downward upon a wax plate (gutta compositions are very often employed) cast upon a sheet of lead. It is then placed under an hydraulic press, by which means a perfect impression of the type is obtained in the wax. The type is then removed from the wax impression, which is then graphited, being generally first slightly warmed to render it just soft, so that it takes the graphite more thoroughly. Of course, it must not be sufficiently heated to blur the sharp edge of the impression. Pieces of stout brass wire are now pushed through the wax until they come in contact with the graphite at various parts where they will not injure the impression of the type. These pieces of wire are to make electrical contact so that when the current is passed it may be evenly distributed.

The prepared impression is now placed in the coppering bath and subjected to a fairly low current until the whole of it has obtained a complete coating of copper. It is now either left in this bath until a sufficiently thick shell has been produced or else it is taken out and placed in the quick-depositing bath, where a much higher current density is employed and the electrolyte is kept well agitated by blowing air through it. In the quick bath the shell may be finished in an hour or two, but may take a day or two in the slower bath (sometimes it is placed directly in the quick bath without being first treated in the slower one). As soon as a sufficiently thick deposit of copper has been obtained, it is removed from the bath, and if the stereo is small the wax is stripped away by hand. But in cases where the shell is of any considerable size, and therefore, liable to be damaged, the wax is usually melted out with hot water or by blowing on steam. The galvano is now thoroughly cleansed from adhering wax and graphite by brushing it in hot water and with caustic soda or dilute hydrochloric acid. The next process is to back up the copper, because as the shell is less than one millimeter thick it is much too thin and fragile to use for printing purposes. But before the backing up metal, which usually consists of lead containing about 6 per cent of antimony to harden it, is poured in, the shell must be tinned, otherwise the lead will not adhere. A very satisfactory way to do this is to first brush the inside of the shell with some soldering fluid;

* Knowledge and Scientific News.

then place the shell face downward upon a flat iron plate and float the iron plate upon a bath of molten metal slightly hotter than the melting point of tin. As soon as the copper shell has become properly heated, powdered tin is sifted over it, care being taken to give it a perfectly homogeneous coat. The tin melts and alloys with the copper, and now the lead can be poured in and it in turn alloys with the tin. After cooling and machining the edges and planing off the excess of lead, the stereo is ready for use.

Facing Stereotypes.—When the copper stereo has been used for some time, owing to the copper being a soft metal, there is a tendency for the sharpness of the impression to become blurred; furthermore, certain printing inks, such, e. g., as red ink, which contain vermilion—sulphide of mercury—act upon the copper and unite with it. In order to get over these difficulties the stereotypes are very often "steel" or nickel faced. The term steel facing is not quite correct, but it has been the custom to call iron when electrolytically deposited steel, because, although its hardness is not due to its carbon contents, yet it has very much the properties of steel. It is more usual to employ iron as a facing rather than nickel, because when used for a considerable time even iron and nickel facings wear off. It is then necessary to reface, but before this can be done it is essential that all of the original facing should be removed. The iron facing is very readily removed with dilute sulphuric acid, which has practically no action on the copper, but nickel is extremely difficult to dissolve, and the copper is very likely to be damaged at the same time. In order to steel face an electrotype, the surface is thoroughly cleansed from all traces of grease and made the cathode in an iron bath; a typical solution is one consisting of 100 grammes of ammonium chloride and 125 grammes iron sulphate, or 150 grammes iron ammonium sulphate in one liter of water. Generally a high current density is employed for one or two minutes, after which a current of 0.4 ampere to the square decimeter is employed for about five or ten minutes, when the stereo is removed and carefully washed and dried. Nickel facing is done in the same manner, a nickel bath being employed in place of the iron bath, and the stereo left in for from seven to ten minutes.

Reproduction of Gramophone Records.—As an illustration of the extreme accuracy of the impressions obtained by electrolytic means, the reproduction of gramophone records might be mentioned. As is well known, the original gramophone record is made on a wax or composition cylinder, the mechanism of the instrument causing impressions of various degrees of fineness to be made upon the cylinder, the thickness depending upon the tone and pitch of the sound to be reproduced. Now, of course, the least fault or unevenness in the reproduction would completely ruin the record. In reproducing a record in copper the wax cylinder is carefully graphited and then, after being connected by means of conducting wires with the negative pole of the source of current, placed in a rapid depositing bath, where it is left for from 70 to 80 hours, a current of from three to four amperes per square decimeter being employed. By this means a good thick negative is obtained which can be used for producing duplicate copies of the original voice.

Dentistry.—Electrotyping is also employed in dentistry for producing mouth plates, etc. A model of the part of the mouth for which a plate is required is taken in wax and a plaster cast obtained from the wax model. The plaster cast is then prepared as already described, and placed in a silver bath, a silver electrotype being prepared; when the silver deposit is sufficiently heavy the model is placed in a gold bath and a heavy coating of gold deposited upon it. Drs. Pfanhauser and Hillischer have also experimented successfully with pure nickel in place of silver or gold.

Deposition Upon Flowers, etc.—I will conclude this article by describing an interesting and artistic method for coating plants, leaves, or even insects with metallic deposits. A flower or leaf will not, under ordinary circumstances, conduct the electric current, therefore it is not possible to coat it with metal. It is, however, possible to render the surface conducting by chemical means in such a manner that the structure of the leaf is not spoilt. If a leaf is dipped into an ammoniacal solution of a silver salt and then exposed to the fumes of phosphorus, the phosphorus reduces the silver salt, and the whole surface becomes coated with a very thin film of metallic silver. The surface of the leaf is now conducting, and if a wire is fastened to the stalk and the leaf placed in a copper-plating bath, a coating of copper of any desired thickness can be deposited upon the leaf. A better method is to dip the leaf or flower into an alcoholic solution of silver nitrate and to then, after draining off the excess of the solution, expose to the action of sulphureted hydrogen gas. By this means a thin and homogeneous film of silver sulphide—which will conduct the electric current—is obtained. The leaf is now placed in the depositing bath and coated with copper or silver as the case may be. If the operation is carefully carried out with a very low current and only a thin coating of metal deposited, all the veins and markings of the leaf remain. Leaves, flowers, and even insects, such as beetles or flies, when coated in this way can be kept for years without withering or decomposing. Of course, the actual leaf or insect is not seen, but is covered with a metallic shell which almost exactly represents the original.

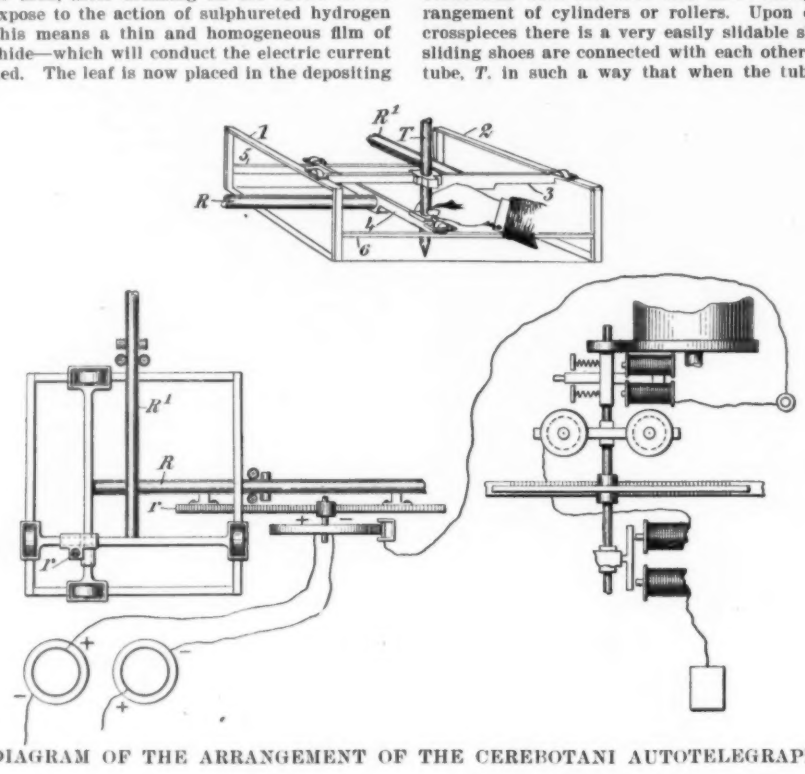


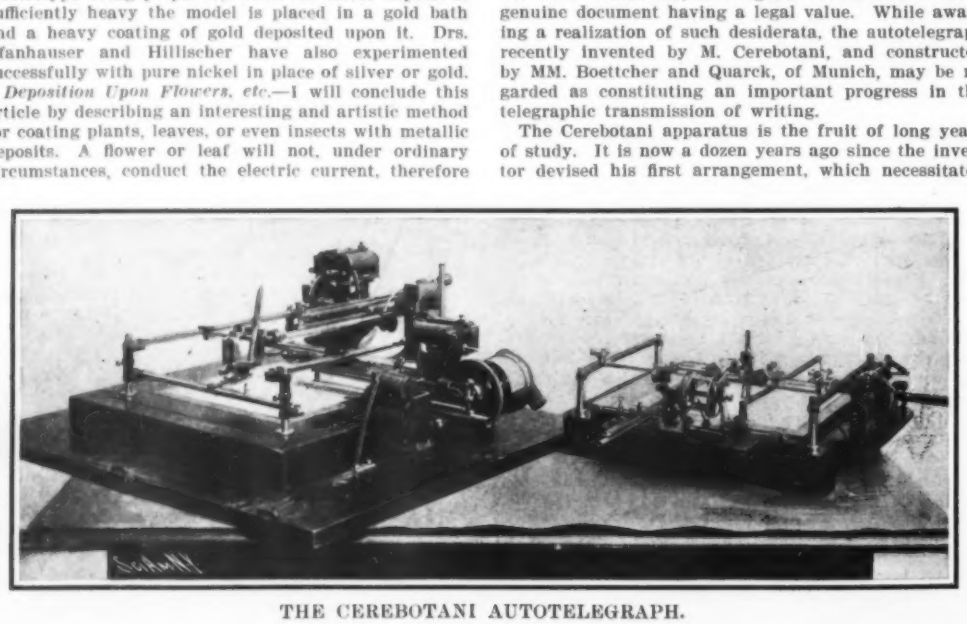
DIAGRAM OF THE ARRANGEMENT OF THE CEREBOTANI AUTOTELEGRAPH.

THE CEREBOTANI AUTOTELEGRAPH.

By the Belgian Correspondent of SCIENTIFIC AMERICAN.

FOR some time past a change has been taking place in favor of the long-abandoned problem of the direct transmission of writing. What is curious is that this change coincides with the increasing development of the printing telegraph. The thing is explainable by the fact that although, on the one hand, the printing telegraph has the merit of clearness, the autotelegraph, on the other, has that of authenticity, proved by the individual characteristics of the writing. The ideal would evidently be a combination of the two systems, or, in other words, an apparatus that should transmit the body of the dispatch and the address in printed characters, and the signature in autographic ones. Under such conditions, a telegram would constitute a genuine document having a legal value. While awaiting a realization of such desiderata, the autotelegraph recently invented by M. Cerebotani, and constructed by MM. Boettcher and Quarck, of Munich, may be regarded as constituting an important progress in the telegraphic transmission of writing.

The Cerebotani apparatus is the fruit of long years of study. It is now a dozen years ago since the inventor devised his first arrangement, which necessitated but three conductors. Not entirely satisfied with this result, which was nevertheless very fair, M. Cerebotani endeavored to diminish the number of wires, and successively devised an arrangement with two wires and one wire. The first arrangement was like the second, except that it was provided with a supplementary wire for lifting the pen. It will therefore suffice for us to describe the second.



THE CEREBOTANI AUTOTELEGRAPH.

Upon two rails (1 and 2) slides a transverse bar, 3, arranged at right angles with anchor bar, 4, situated lower and likewise sliding upon two rails (5 and 6) at right angles with the first two, but placed in a lower position. These crosspieces are in permanent connection with two rods that move freely in an arrangement of cylinders or rollers. Upon each of the crosspieces there is a very easily slidable shoe. These sliding shoes are connected with each other by a small tube, *T*, in such a way that when the tube is moved from one point to another, it shall always remain perpendicular to the crosspieces and that there shall be no point upon the writing table that cannot be reached by the small rod, that is to say, by the point of intersection of the two crosspieces. Every motion of the vertical tube, *T*, involves a motion of the two rods, *R R'*, attached to the crosspieces, and this motion is transmitted to the receiver and there brings about the different positions of the writing tube. Since the receiver and transmitter are identical, the result is that there is an analysis of the writing at the former and a synthesis of it at the latter.

The transmission is obtained by a rack, *r*, secured to one of the rods, *R*. A pinion, a wheel, an interrupter, and a commutator are the parts necessary for transmitting the motion of each rod to the receiver.

Two batteries are connected with the commutator by positive and negative conductors. First one circuit and then the other acts upon the wheel according as the rod is displaced in one direction or the other. If, for example, it is displaced to the right, the negative will be interrupted and the positive will be in circuit, and if it is displaced to the left a contrary result will be the consequence. The current (positive or negative) that starts from the transmitter reaches the receiver through the commutator. It is these current impulses that determine the position of the rods at the receiver. For this purpose, the rods of the receiver are provided with a double rack device in the center of which there is a pinion that always turns in one direction, and, at the same time, descends or rises, so that, when it engages with the lower rack, the rod is displaced in one direction, and naturally carries the entire device along with it, while if it engages with the upper rack, the rod will be displaced in the contrary direction.

The line, through which positive and negative currents alternately pass, ends at an electro-magnet, which counteracts the force of two springs, and successively attracts and sets free the anchor of an escapement, thus permitting the revolution, by one tooth, of a cogwheel actuated by a spring, the effect of which motion is to cause the advance of the rack device in one direction or the other according as the pinion of the escapement wheel engages with the upper or lower rack. Since the transmitter and receiver are of identical construction, it can be readily seen that when the wheel of the transmitter and the number of current interruptions that are produced therein correspond to the same number of teeth of the escapement wheel of the receiver, the rods of the latter will exactly follow the motions of those of the first. The current afterward passes to a second polarized electro-magnet, which operates only on positive current. When actuated, this electro attracts an armature that carries the pinion. It is thus that the latter engages with the upper rack (when the current is positive) and with the lower one (when it is negative). A click keeps the pinion raised as long as it is not liberated through the action of a third electro, likewise polarized, but acting on negative current, this being to prevent the effect of the frequent interruptions of the current upon the pinion.

In the preceding arrangement, two conductors are therefore required, one for each rod, but in the following arrangement there is but one conductor. In this form, a contact and its accessories close upon a local battery in the circuit of which there is an electro. A two-armed lever closes the circuit of a second local battery when one of the rods is displaced, and two electros are thereby put in circuit. The motion of the rod in a

contrary direction opens the circuit. The second rod is provided with an identical arrangement.

When the above-mentioned contact is established, the electro attracts its armature, and the line battery, the positive of which is grounded, is connected by the negative with the transmission conductor which unites the transmitter and receiver.

If the current is established as a consequence of the motion of the rod toward the left, the second local battery will be put in circuit at the same time, and the two electros dependent upon it will attract their armatures, and some cells will be added to the line battery and to a fourth battery. In this manner, negative currents will pass into the line when the rod is displaced toward the left, and such currents will be more intense than the positive ones just mentioned.

The same things occur with the second rod, except that the line battery dependent upon this rod has its negative grounded and its positive in the line. The current that passes into the line is therefore positive, and, according to the direction of the rod's motion, is now more and now less intense. In the line, there are therefore now positive, now negative, now weak, and now strong currents. Here intervene the fourth and fifth batteries, arranged like the line batteries and operating as has been described above. For this purpose, the contacts and armatures of the above-mentioned electros are provided with two tongues insulated from each other. The front tongue of the second contact is connected with the second line battery, and the back one, as well as that of the first armature, with a conducting wire. Finally, the front tongues of the armatures are connected with the line, and the back tongue of the second armature is connected with a sixth battery. The back tongue of the first contact is connected with a wire coming from a supplementary electro in relation with the fourth and fifth batteries, while the front tongue is connected with the first line battery..

When the two armatures are attracted at the same time, the two line batteries are simultaneously connected with the line by the front tongues; but, at the same moment, owing to the back tongues, an auxiliary circuit is established from the fourth battery, through the back tongues, the supplementary electro and the various wires, to the sixth battery. The supplementary electro is then excited and attracts its armature. Upon descending, the point of this armature, connected with the line, strikes in succession two contacts that are connected respectively with the fourth and fifth batteries. Since these batteries are arranged like the two line batteries, properly so called, and operate the same with respect to the motions of the rods, the two armatures already mentioned are replaced (thanks to the armature of the supplementary electro) by currents of equal value (that is to say, of a value corresponding to the direction of the displacement of the rods) that enter the line one after the other.

The receiver is thus reached by currents of different potential and intensity that cause the operation of it in a manner analogous to that of the two-wire receiver.

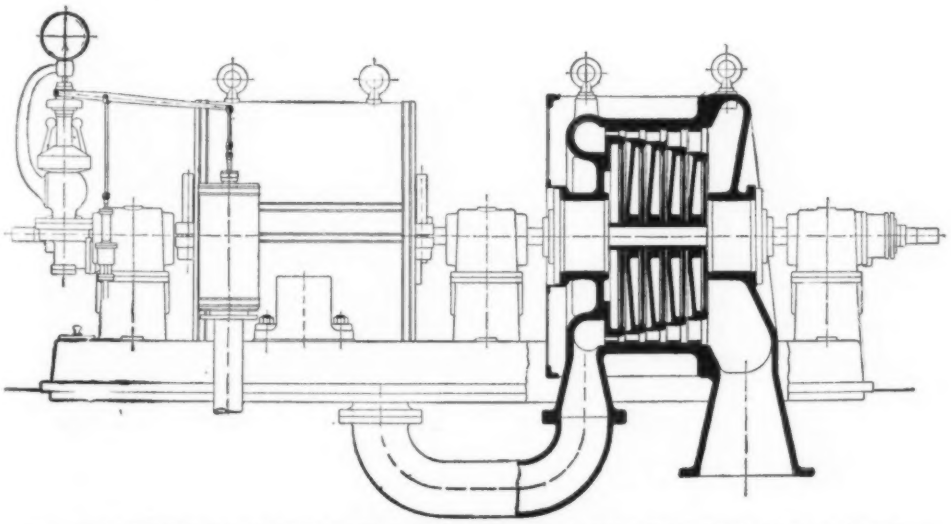


FIG. 1.—DETAILS OF NEW SWISS STEAM TURBINE MANUFACTURED BY ESCHER, WYSS & CO., OF ZURICH, SWITZERLAND.

THE ZOELLY STEAM TURBINE.

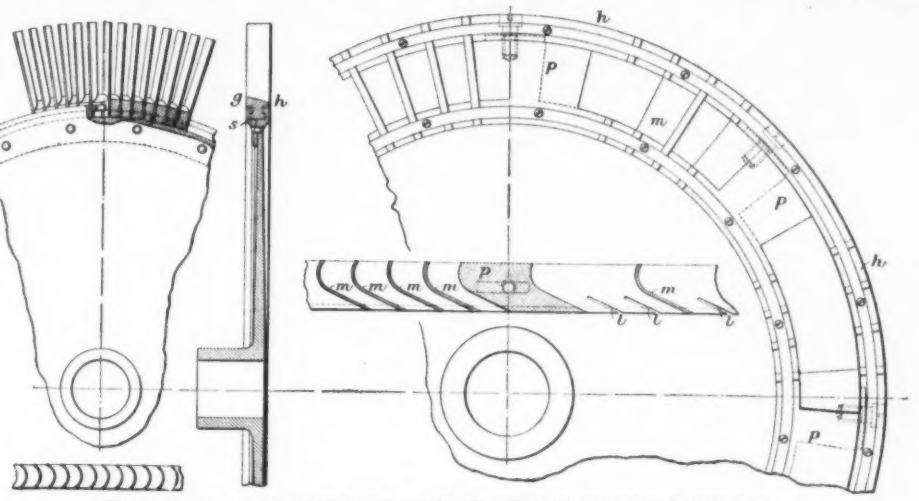
By FRANK C. PERKINS.

A NUMBER of very successful types of steam turbines have recently been placed upon the market in this country and Europe by prominent electrical manufacturers. Some of the tests made on the most recent installations have been most satisfactory, and leave one to predict a most important future for this class of prime movers.

Among the earliest steam turbines to meet with practical success should be mentioned the De Laval, but this particular type has not been constructed in very large sizes for central station and power plants requiring large units. The Parsons steam turbine is probably the best known, and is in successful operation in many European countries as well as in the United States. The Westinghouse-Parsons type of steam turbine is being installed throughout the States extensively by the Westinghouse Electrical Manufacturing Company. On the continent of Europe the Parsons turbine has been utilized in a number of central stations. It is being manufactured at Baden, Switzerland, by Brown, Boveri & Co.

Among the more recent types of steam turbines introduced in the United States might be mentioned the Curtis as constructed at Schenectady by the General Electric Company, this being of the vertical type and built in sizes up to 5,000 kilowatts, the tests of these units being of particular interest. The Rateau steam turbine has been found to be one of the most successful types designed in Europe, as will be noted by the accompanying data of test. This turbine was designed by Prof. A. Rateau, and is being extensively installed by Sautter, Harle & Cie., of Paris. In Germany the Riedler-Stumpf turbine has created a great deal of interest, and is built in large sizes of several thousand kilowatts with both vertical and horizontal shaft. The Riedler-Stumpf turbo-generator is constructed for supplying direct current as well as alternating current, in some cases two dynamos being connected on the same turbine shaft.

Another European steam turbine of Swiss construction has recently been installed abroad by Escher, Wyss & Co., of Zurich, Switzerland. This construction



FIGS. 2 AND 3.—DETAILS OF ZOELLY STEAM TURBINE WHEEL.

is known as the Zoelly steam turbine, and is shown in the illustrations. It may be of interest to consider the details of a recent test of one of these turbines of 500-horse-power capacity. A number of these turbines of large power have been installed in central stations in Europe. In the United States Escher, Wyss & Co. are represented by the Allis-Chalmers Company. In France one of these turbines of 1,500 horse-power, operating at a speed of 1,500 revolutions per minute, has been installed at Creusot by Schneider & Co., and a number of turbines ranging in size from 500 horse-power to 1,500 horse-power and in speed from 1,500 to 3,000 revolutions have been placed in operation in various central stations by the Siemens Schuckert Werke of Berlin. A Zoelly steam turbine and electrical generator of 700 horse-power has been in operation for some time at the Centrale Muhlhausen i. Thur, and another of the same capacity operating at 3,000 revolutions per minute at the Centrale Brakpan near Johannesburg in South Africa. There are two units of 1,500 horse-power at the Centrale Nonnendamm in Berlin, and two units of 850 horse-power at the electrical power station of the Teltow canal. The municipal electric power station at Neuenburg in Switzerland is equipped with a turbine of 600 horse-power operating at 2,000 revolutions per minute, and an 850-horse-power unit has been installed at Dusseldorf at the Dusseldorfer Rohren- und Eisenwalzwerke. The accompanying illustration, Fig. 1, shows the Zoelly steam turbine directly coupled to an electrical generator, while Fig. 2 shows the detailed construction of the low-pressure turbine, and Figs. 3 and 4 the details of the turbine wheel.

This turbine, it will be noted, is one of the impulse type and is divided into two sections for the high-pressure and low-pressure turbine, each having a separate compartment with a bearing between them. The low-pressure section is constructed practically the same as the high-pressure section, except that the steam passages are much larger, as the steam expands as it passes through the turbine, and therefore the steam passages must necessarily increase in area to provide

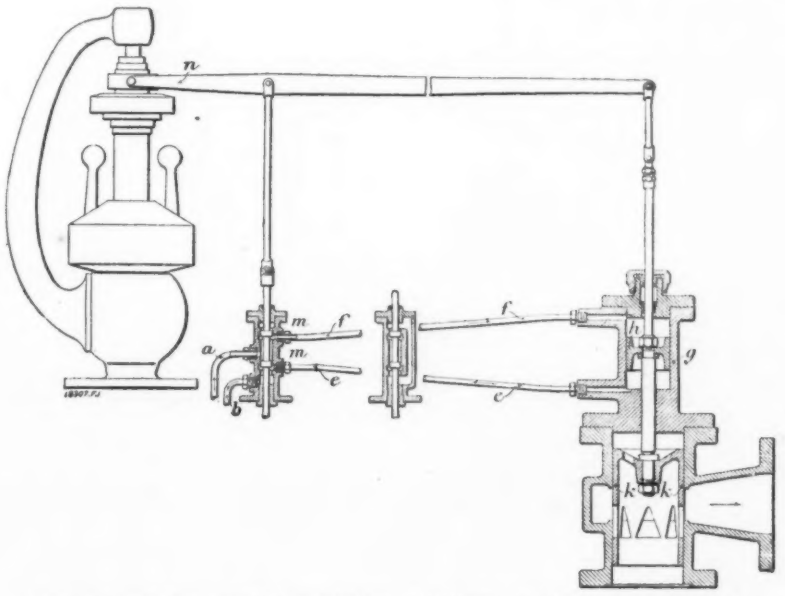


FIG. 4.—ZOELLY STEAM TURBINE THROTTLE AND CENTRIFUGAL GOVERNOR.

for the increased specific volume of steam. It will be noted that the design is that of a multi-step turbine, the steam being expanded in stages, and the various parts are so designed as to permit of very high peri-

pheral speed without difficulty, while the number of steps is reduced to a minimum.

There are ten rotating wheels or circular disks attached to the same shaft, with curve plates on their peripheries, and for each wheel there is a set of guide vanes, which direct the steam against the rotating plate. The steam first enters at one end, and is directed by the guide plate to the vanes of the first wheel, and the guide chambers are so designed as to allow the steam to partly expand to a lower pressure, and thereby partially convert the potential to kinetic energy, and this is given up upon passing through the live wheel, the steam leaving it at a low speed. The function of the guide passages is that of the De Laval steam nozzle. Each wheel rotates in a chamber by itself, the walls of which are formed by the disks, to which the guide veins are attached. The steam enters the first high-pressure compartment after first passing through the throttle valve operated by the governor noted in the accompanying illustration, Fig. 4. The steam is then passed through another guide wheel expanded down to a lower pressure, and again directed to another running wheel, giving up energy in proportion to the reduction and pressure. The steam then passes through the passages of the next guide disk, and is directed against the plates of the next rotating wheel after expanding to a lower pressure. After passing through the high-pressure compartments and the last step of the low-pressure compartment, the steam is exhausted into the air or into a condenser.

Each of the casings is mounted separately on the bedplate, and is constructed of cast steel, so designed that the top half of each casing may be lifted off. The bearings are fastened directly to the bedplate, and are not connected in any way with the casings, so that the heat cannot be conducted as easily from the steam casings to the bearings. The bearings are lubricated by a circulation of oil, which is forced through pipes into the bearing by a small rotary pump driven from the main shaft by a helical gear. It is claimed that as each wheel is running in a medium of uniform pressure, any end thrust of the shaft is eliminated, and the leakage through the clearance spaces between the guides and the wheels is reduced to a minimum. The Rateau steam turbine and others of designs similar to the Zoelly turbine differ principally in the details of construction of the turbine wheels, which are noted in the accompanying drawing. The wheels or disks are forged from Siemens-Martin steel from one piece, including the hub, and a T-slot is machined out of the circumference, to hold the plates and their distance pieces, one side of the slot being closed by a rod iron ring riveted to the disk. The plates are constructed of nickel steel, and are highly polished to resist erosive action, and it will be noted are radial, the cross-section decreasing as the radius increases, thus reducing the stresses due to centrifugal force to a minimum. The material used is a non-rusting one, and is so hard that little wear takes place at the edges of the vanes, and the high polish reduces the friction losses to a minimum. The peripheral velocity can be very high, as the load is constant both in amount and direction, and so it is claimed the number of steps in this class of turbine can be very much smaller than in turbines which do not allow such high velocity, and by the reduction of the number of steps the cost is reduced, as well as the comparative size. The wheels are very carefully balanced after being completed, and are tested at very much higher speeds than those ordinarily required of the turbine wheel.

The accompanying table shows the results of a series of eleven trials in a test of a 500-horse-power Zoelly steam turbine using superheated steam and dry, saturated steam, three of the trials indicated using superheated steam, and the remaining eight dry, saturated steam. The turbine was tested by Mr. Wagner, of the Zurich electricity works, and by Dr. Stodola, of the Zurich Polytechnikum, while the instruments used were calibrated before and after the experiments by Prof. Weiss of the latter institution, the voltmeters and ammeters being supplied by Siemens & Halske, of Berlin. The polyphase generator was run under a constant pressure of 600 volts, and a variable water resistance was used, so arranged that by increasing or decreasing the quantity of water, a constant load could be kept on the turbine. On each phase two ammeters were employed, one reading up to 300 amperes for small loads, and the other indicating to double this current for larger loads, and two voltmeters were also employed, the switchboard arrangement being such that readings could be taken in all three phases.

The table shows the results of the various trials with dry saturated steam and superheated steam, the total steam consumption per hour being given in pounds, as well as the steam consumption per effective kilowatt hour. The diagram of the governor and throttle valve shows the former to be that of the centrifugal type acting on a relay valve, which is connected on two sides with pipes leading from a reservoir of oil under pressure supplied by a rotary pump, a return pipe leading to the suction well of the pump. The moving part of the valve is attached to the same valve stem as the piston, *h*, in the cylinder, *g*, noted at the right in the drawing. It is so arranged that if the load on the turbine is decreased, the increase in speed resulting raises the governor lever, and valve, *m*, makes the direct connection between *a* and *f* and *e* and *b*, so that the liquid entering the cylinder, *g*, forces the piston down, and thereby closes the throttle valve a certain amount, reducing the pressure of the entering steam.

TESTS ON A ZOELLY STEAM TURBINE OF 500 BRAKE-HORSE-POWER.

	Dry Saturated Steam.								Superheated Steam.		
Test number	1	2	3	4	5	6	7	8	9	10	11
Net power in K. W.	363.06	367.05	334.51	240.1	182.22	80 13	....	....	391 66	389.6	390.4
Revolutions per minute (speed)	2997	2995	2977	2983	2984	2995	2995	30 0	2972	2973	2968
Pressure in steam pipe, lbs. sq. inch, abs.	158.7	158.7	155.	156.6	156.	157.	157.	159.1	189.2	186.7	160.1
Superheat, degrees Fahr	....	....	....	....	....	....	....	....	135.	153.	109.
Pressure, lbs. sq. inch, abs. (After passing through	143 6	143 6	128.4	98.4	77.8	43.7	17 3	10.6	138.2	138.2	139.4
Superheat, degrees Fahr (governor throttle valve)	....	....	....	....	....	....	30.4	53.	102.	107.	101.
Pressure in exhaust pipe, lbs. sq. inch. steam saturated	1.02	1 03	0.965	0.934	0 940	0.741	0 725	0 731	0.928	0.944	0.984
Vacuum in condenser, inches of mercury	....	28.5	28.5	28.4	28.3	28.6	28.6	28 5	28.7	28.7	28.7
Steam consumption, lbs. per hour	7993	8327	7428	5778	4083	2050	1025	651	7454	7335	7730
Steam consumption per kilowatt hour (pounds)	21.76	21.45	22 19	24.06	25.70	33.07	...	....	19.05	18 80	19.80

PRECIOUS METALS RECOVERED BY CYANIDE PROCESSES.*

By CHARLES E. MUNROE, Ph.D.

THE returns for 1902 show that during that year there were 109 establishments, in 12 different States, using a cyanide process for the extraction of the precious metals from tailings or ores. Of these establishments, 29 cyanided the ore or tailings without other treatment; 27 crushed the ore previous to cyaniding; 5 concentrated the ore; 20 combined amalgamation for coarse gold with cyaniding for the finely-divided gold; 18 combined concentration and amalgamation with cyaniding; 6 combined smelting, and in some instances amalgamation with cyaniding; and 4 combined chlorination, with and without amalgamation, with cyaniding. During the census year these establishments treated 3,089,673 tons of ore and 199,689 tons of old tailings, or 3,289,362 tons in all, and produced 776,050 fine ounces of gold, valued at $15,972,268, and 1,741,546 fine ounces of silver, valued at $871,878; the products included also 15,000 pounds of copper, valued at $1,670; 741,000 pounds of lead, valued at $12,494; and 8,726 pounds of mercury (recovered from tailings), valued at $5,620, so that the total value of all the products was $16,863,930.

The returns showed directly that of the total output of precious metals 289,305 ounces of gold, valued at $5,947,888, and 560,872 ounces of silver, valued at $287,614, were extracted from 1,156,643 tons of ore and tailings by means of some cyanide process of recovery. It is estimated that in those operations in which amalgamation, chlorination, smelting, or several of these processes were combined with a cyanide process, gold to the value of $2,000,000 and silver to the value of more than $300,000 were recovered by cyanide processes. Hence, by the use of such processes there were produced in the United States, in 1902, gold with an estimated value of about $8,000,000, and silver with an estimated value of about $600,000.

A detailed summary for cyaniding mills is presented in the report on gold and silver.

OCCURRENCE OF GOLD.

Gold, when found *in situ*, is generally in quartz veins intersecting metamorphic rocks, and to some extent in the wall rock adjoining these veins. It may occur either free or combined apparently with tellurium and perhaps selenium, and it is associated with pyrite (iron disulphide), chalcopyrite (copper-iron sulphide), galena (lead sulphide), sphalerite (zinc sulphide), mispickel (iron sulph-arsenide), and many other minerals containing sulphur, antimony, bismuth, cobalt, nickel, the platinum group of metals, etc. On exposure to the atmosphere these minerals may undergo chemical changes, whereby many of their constituents are converted into other compounds, while the metallic gold is set free. Atmospheric action also breaks the veinstone into fragments, which are ground to smaller particles by attrition. When suspended in flowing water the superior density of the gold causes the particles, together with the heavier particles of the vein matter, to settle out, through a natural concentrating action, in an obstructed portion of the stream, forming alluvial deposits or placers. Through geologic changes such alluvial deposits may again be formed into rock masses, the gold being found in conglomerate rock cemented together by finely-divided material, which may be barren or may itself contain gold. When the gold occurs free in quartz or in a weathered vein, it is called a free-milling ore; when it is intimately associated with sulphurets and similar substances, it is called a refractory ore.

Free gold, as found in nature, is never pure, being alloyed to a greater or less degree with silver, copper, and other metals. It occurs in quartz in the form of strings, scales, or plates, and at times in considerable masses of aggregated crystals; the scales are often so small as to be invisible to the naked eye, so that quartz showing no "color" and no evidence of gold on panning may yet yield a considerable percentage on assay. The metal is very irregularly distributed through the quartz, being disseminated throughout its mass, and also occurring in cavities; it is in these cavities that the largest masses and most perfect crystals of gold are found. Alluvial gold occurs usually in flattened scales of different degrees of fineness, the size and shape depending partly on its original condition in place, and partly on the amount of attrition it has undergone in transport. The average fineness of the gold in a placer is determined by the assorting action of the running water that transported the materials from their point of origin; the coarser particles, requiring rapid currents to transport them, are dropped first, while the finer particles are carried long distances, sometimes scores of miles. Another agent which has borne no inconsiderable part in this transportation, delivering its burden to the streams at its base, is the glacier.

MINING AND RECOVERY OF GOLD.

Placers.—In the earlier operations in auriferous districts, the gold is obtained from the placers by the use of the pan, rocker bumper, "long tom," and sluice, and by hydraulicking. The hydraulic process was employed by the Romans, but it has probably reached its greatest development in this country, since its introduction in California in 1853. In this process, as in the workings of nature, the energy of a head of water dislodges the gold-bearing detritus, and the buoying power of water at different rates of flow separates the heavier from the lighter particles. Even in ancient times, these methods were often supplemented by the use of mercury, either in the liquid state or exposed on plates, to catch and retain, by amalgamating with them, the lighter particles of gold, which would otherwise flow away with the dirt. More recently, dredging has been resorted to in order to recover the gold-bearing alluvium from river beds, and even from deposits in former river beds, over which have since formed deposits of silt so deep that the water has been turned from its course.

Free Milling Ores.—When the placers have been exhausted, attention is given to the recovery of the gold *in situ* by vein or quartz mining. As long as the ore is free milling, the process consists in detaching it from the vein by drilling and blasting. It is then crushed by stamps, crushers, or rock breakers, and treated, like placer deposits, by sedimentation and amalgamation. The machinery and devices used for concentration, separation, and amalgamation have been very highly developed, especially during the past century. During the last half century treatment by chlorine has been resorted to for the recovery of the fine gold.

Refractory Ores—Old Methods.—When refractory ores are reached, the methods of mining are changed. Before the introduction of the cyanide process, the gold in these ores was extracted by smelting, chlorination, or other elaborate chemical process, the degree of success depending on the richness of the ore in precious metals or in other materials that would yield a profit on the operation. Thus the precious metals associated with galena were alloyed with the lead reduced from it by smelting, and subsequently recovered by processes such as that of Parkes or Pattison; iron pyrites carrying the precious metals were roasted to convert their sulphur content into sulphuric acid, and the precious metals were then recovered from the pyrite cinder, and these methods are still employed. Copper pyrites, which usually carries gold and silver, and has long been a source from which these metals were obtained, has become a notable source of supply, since the development of Manké's method of bessemerizing copper mattes and the successful refining of this impure copper by electricity. These are a few among numerous methods proposed or used for the treatment of refractory ores. In the development of the milling processes it has become possible to assort the ore into different concentrates, each of which is treated by that process which will most effectively and economically extract the gold and other valuable substances present.

On account of the cost of transportation or treatment, however, at many mines only the most valuable of the ores could be worked profitably; moreover, after the greatest possible value had been extracted by concentration or by some other comparatively crude form of treatment, the tailings—carrying with them, in the aggregate, much gold and silver—were disposed of as inexpensively as possible. Thus, in the early days of the Comstock lode in Nevada, which has yielded gold and silver valued at more than $400,000,000,* the treatment of the ores was limited to mill batteries, amalgamating pans, and settlers, the tailings—still containing notable quantities of the precious metals—being deposited in the canyons leading to the Carson River. Later, blanket sluices, riffles, and other devices were employed to catch the rich sulphurets that had escaped previous treatment, as well as quicksilver and amalgam from the plates; in addition, restraining dams and reservoirs were constructed at favorable points in the two canyons, and along the edges of the river, to catch the tailings and the rich chloride slums or settlings, but both the dams and their accumulations were sometimes swept away by winter floods. Since the erection, in recent years, of several cyanide plants at Silver City and Six Mile Canyon to work these tailings, it has been estimated, on the basis of the values recovered from the tonnage work, that the value of

* Census Bulletin.

* Report of the Director of the Mint upon the Production of the Precious Metals during 1902, page 158.

the precious metals swept into the river and spread over its erratic bed and sandy flats aggregated $60,000,000. This estimate is supported by the results obtained in attempting to recover some of these values from the river bed by dredging and other means.

All of the long-used methods have been open to criticism with regard to efficiency or economy. Thus, in the working of placers or free milling ores, sometimes the finest particles of gold were not precipitated by the riffle bars or caught on the blankets, but floated away with the slimes; again, the grains of gold were often "rusty," or so coated as to refuse to amalgamate when brought in contact with the mercury, and hence, in spite of the use of metallic sodium, or of potassium cyanide and other chemicals, much gold escaped; or the presence of lead, copper, arsenic, antimony, or other substances in the ore caused the mercury to become "foul," and therefore unable to take up gold. These, combined with other causes of loss, have led to the estimate that although gold to a value of over $1,000,000,000 has been produced in California since 1848, "yet more has been wasted in milling and hydraulic mining by being washed down the rivers and even to the ocean."

Such were the conditions that existed in 1888, when, by tests made on a large scale, it was demonstrated that the cyanide process for the recovery of gold and silver from low-grade ores was of practical value and low cost, making it possible to work profitably the large bodies of low-grade ore scattered over the earth, and the enormous piles of tailings accumulated around both abandoned and active mines and mills and being continually added to as mining and milling proceeded.

THE CYANIDE PROCESS.

History.—According to Hoefer,* prussic acid appears to have been known to the Egyptian priests, who used it for poisoning initiates guilty of divulging the sacred mysteries. According to Eissler,† the fact that gold when in a fine state of division was soluble in cyanide of potassium was already known in the middle ages, when the gilding of metals was carried out by jewelers and alchemists by the use of gold in cyanide solutions. Unless potassium cyanide was at that time made from prussic acid obtained from vegetable sources, it is difficult to reconcile this with the statements made by Watts, by Roscoe and Schorlemmer, and other authorities, that potassium ferrocyanide was discovered by Macquer in 1752 and hydrogen cyanide by Scheele in 1782; for these, particularly the former, are the present sources of potassium cyanide. It has long been known, however, that in the kernels of the bitter almond, peach, apricot, plum, cherry, and quince, in the blossoms of the peach, sloe, and mountain ash, in the leaves of the peach, cherry laurel, and Portugal laurel, in the young branches of the peach, in the stem bark of the Portugal laurel and mountain ash, and in the roots of the mountain ash, there occur certain glucosides which, through the action of an enzyme in the presence of water, become hydrolyzed, yielding hydrogen cyanide, or prussic acid, as one of the products.

The solubility of gold and silver compounds in cyanide solutions was demonstrated by Scheele on pages 405 and 406 of his chemical essays. According to Gore,‡ it was the reading of this passage in Scheele's work which in 1840 suggested to John Wright, of Birmingham, England, the suitability of cyanides of gold and silver, dissolved in solutions of alkaline cyanides, for use in electroplating. This plan was immediately tested with solutions of silver, first in potassium ferrocyanide and later in potassium cyanide, and the results were so successful that this method of electroplating was embodied in a British patent issued to G. R. and H. Elkington, March 25, 1840. This patent became the basis of the arts of electro-silvering and electro-gilding which have been so extensively practised ever since. It was in 1840, also, that the solubility of the metals themselves was taken advantage of, for in Mason's "separate battery," devised in that year, the necessity of supplying additional metallic salt to the bath as the deposition went on was obviated by the use of an anode composed of the metal to be deposited on the object suspended at the cathode.

In "The Cyanide Process, its Practical Application and Economical Results,"§ Scheidel says:

"The first record, in scientific literature, of experiments in which metallic gold was dissolved in a cyanide of potassium solution consists in Prince Pierre Bagration's paper in the Bulletin de l'Academie Imperiale des Sciences de St. Petersbourg, 1843, tome 11, page 136. Bagration, who alludes to Elkington's process, preserved cyanide of potassium solution in a dish gilded on the inside. He noticed that after eight days the whole gold surface had been attacked. He experimented then with finely divided gold under the influence of the galvanic current. The latter he soon recognized as not of any benefit in the dissolving process. He precipitated the gold out of the cyanide solution by means of the electric current on a cathode of copper. Continued experiments proved the advantage of higher temperature during the dissolving process, and taught the precipitation of gold from its still warm solution by means of silver or copper plates, without the electric current. The higher temperature had, however, the disadvantage of the silver and copper being strongly attacked by the cyanide solution during the precipitation process. Bagration extended his experiments to solutions of ferrocyanide, which he found to act like cyanide, but in a much less degree. He further studied the solubility of gold in the form of plates in cyanide and found it to be dissolved in such form at a considerable rate at a temperature of 30 to 40 deg. C. He noticed the influence of the air on the reaction. Bagration believes that hydrocyanic acid in a state of generation is a gold solvent, and he concludes his paper with the remark that in the future cyanide of potassium must be enumerated among the solvents of gold. L. Elsner published in J. fr. Chem., 1844, page 441, his observations on the reactions of 'reguline metals' in an aqueous solution of cyanide. He found that gold and silver were dissolved in potassium cyanide without decomposition of water. 'The dissolution of the metals is, however, the consequence of the action of oxygen which, absorbed from the air, decomposes part of the cyanide.' His reaction has been expressed by others in the following equation:

$$2\,Au + 4\,KCy + O + H_2O = 2\,AuKCy_2 + 2\,KOH$$

(Gold.) (Cyanide of potassium.) (Oxygen.) (Water.) (Auro-potassic cyanide.) (Potassic hydrate.)

"It is generally called Elsner's equation. Some years after, Faraday made use of the solubility of gold in cyanide solution for reducing the thickness of gold films. (Experiments on the relations of gold and other metals to light, Transactions of the Philosophical Society, 1857, page 147.) The basis of the most modern process for the extraction of gold was thus provided."

In confirmation of Elsner's theory as to the action of oxygen, which has been disputed, it may be noted that V. Lehner has recently shown* that gold will dissolve in common acids, like sulphuric and phosphoric, if oxygen be present in the solution, and that the solubility of gold in selenic and telluric acids is due to the fact that at the temperature which obtains in the reaction these acids are themselves broken up into dioxides and oxygen.

The first instance of an attempt to apply this solvent action of the cyanides to the extraction of precious metals from their ores or other bodies containing them appears in United States patents 61,866 and 62,776, issued to Dr. Julio H. Rae, of Syracuse, N. Y., on February 5 and March 12, 1867. Dr. Rae claimed the use not only of potassium cyanide as a solvent for the precious metals in the ore, but also of an electric current in precipitating them from the solution, and of rotatory or movable electrodes. This was followed by United States patent, 229,586, of July 6, 1880, to Thomas C. Clark, of Oakland, Cal., who roasted his ore to a red heat, and placed it, in this condition, in a cold bath containing salt, prussiate of potash, and caustic soda; United States patent 236,424, of January 11, 1881, to H. W. Faucett, of St. Louis, Mo., who subjected hot crushed ores, under pressure, to the action of sodium cyanide in solution; and United States patent 244,080, of July 12, 1881, to John F. Sanders, of Ogden, Utah, who treated his ore with potassium cyanide and glacial phosphoric acid. But in each of these last three patents the object was to cleanse the gold previous to amalgamation, potassium cyanide having been used for a considerable time, in California and Australia, for removing the coatings from rusty gold in the pan amalgamation process.

In 1884 Astley P. Price applied for British patent 5,125, for the use of zinc in a state of fine division in precipitating gold or silver from solutions containing them. On July 28, 1885, United States patent 323,222 was issued to Jerome W. Simpson, of Newark, N. J., covering the extraction of gold, silver, and copper from their ores by means of solutions containing potassium cyanide, ammonium carbonate, and sodium chloride, and the subsequent precipitation of the dissolved metals by means of pieces or plates of zinc suspended in the solution. A caveat for the use of cyanide was filed in the United States Patent Office by F. M. Endlich and N. W. Mühlenberger, during the same year, but was subsequently abandoned. At Park City, Utah, about the same time, Louis Janin, Jr., made experiments with cyanide in extracting silver and gold from ores, which led to his filing a caveat on May 1, 1886. He did not press this to an issue, but he published his results in the Engineering and Mining Journal, 1888.† W. A. Dixon also made experiments with cyanide on Australian ores, and recorded his results in a paper read before the Royal Society of New South Wales.

The cyanide process acquired commercial value in 1887, when John S. MacArthur and W. Forrest, of Glasgow, Scotland, applied, on October 19, for their English patent covering the use of dilute solutions of cyanides in the extraction of the precious metals. Later they obtained a patent for the use of zinc as a precipitant in a particular state of subdivision.

The commercial value of the cyanide process was demonstrated by tests made on a large scale, with ore from the New Zealand Crown mine, in June and July, 1888. Commercial success dates from the introduction of the MacArthur-Forrest process, in 1890, in the Witwatersrand gold fields in South Africa, the first cyanide plant in the world for treating tailings having been erected at Johannesburg in April, 1890.‡ In the Witwatersrand alone, at the end of 1891, there were six companies treating tailings, by the cyanide process; at the end of 1892 there were 22; and at the end of 1893 there were thirty-two, with a record of 143,500 tons per month treated. By the use of this process there were recovered in the Rand 286 ounces of gold in 1890, 34,862 ounces in 1891, 178,688 ounces in 1892, 330,510 ounces in 1893, 714,122 ounces in 1894, 753,490 ounces in 1895, and 702,704 ounces in 1896; the output then increased up to September, 1898, when the commencement of active hostilities in the Boer war interfered with the active working of the mines.

Methods.—The cyanide process consists in lixiviating the finely powdered ore with a dilute solution of an alkali cyanide, drawing off this solution when charged with the precious metals, and precipitating these metals from the solution. In the patents of MacArthur and Forrest the claims were made for the use of dilute solutions of cyanide (not more than 8 parts of cyanogen to 1,000 parts of water); the employment of caustic alkalies for neutralizing acid ores, prior to their digestion in the cyanide solution; and the use of zinc, preferably in a filiform condition, as a precipitant. The cyanide first used was potassium cyanide, but cyan-salt, which is a mixture of sodium and potassium cyanides, has come into extended use. The tailings, or a charge of ore crushed to the desired fineness, are placed in the leaching vats or tanks and, if acid, given a preliminary treatment with lime or sodium hydroxide, which is generally washed out before further treatment. The ore is then subjected to the action of the cyanide solution, which is usually admitted at the bottom of the leaching vat; after digesting for a length of time, depending on the character of the charge, its fineness, its freedom from slimes, and the strength of the cyanide solution, the solution containing the precious metals is drawn off and the operation repeated. According to Elsner's equation and the elaborate investigations of MacLaurin and Christy, the presence of oxygen in the solution is essential, hence many operators use sodium peroxide or other oxidizing agents with their cyanide solutions.

The leaching or percolation vats vary much in form, dimensions, and construction. Thus they may be of wood, barrel-shaped, 22.5 feet in diameter and 4 feet deep, and holding a charge of 30 tons; or of concrete, rectangular, 50 by 40 feet in area and 4 feet deep, and holding 150 tons.

The following facts from Packard's paper on "The Cyanide Process in the United States"* indicates the wide ranges of variation in methods:

In the Mercur district the ore is covered with solution, which is allowed to stand from thirty minutes to six hours and then drawn off. This operation is repeated from eight to thirty-five times. Here the material leached is so coarse that there is no danger of "packing." Each operation of covering takes from two to six hours. A few mills cover the pulp with solution, allow it to stand forty-eight to ninety-six hours, draw it off, and wash. Many of the mills follow the strong solution with a wash of weak solution (one-tenth per cent or less). This is in turn followed by a water wash, which flows through the zinc boxes into the weak solution tank and becomes the first wash for the next charge.

In the extraction processes referred to above the treatment with cyanide solutions is accomplished by percolation. This method is widely and successfully used, but it has its disadvantages. If the material treated is a clean sand, the solution penetrates throughout the mass, exerting its full solvent effect, and the subsequent draining and washing are easily accomplished. But if the ore contains some kind of rock which is converted by the crushing into a powder that when moistened produces slimes—a formation which is most marked when the rock is of a clayey nature—the presence of these ore slimes in the leaching vats may retard or even prevent percolation, according to their amount and character. In working ores of this kind, the difficulty has been obviated by coarse crushing, but in that case gold is lost, because the solvent cannot penetrate through the coarser granules of ore to the inclosed grains of metal. To overcome these defects in the process, resort is had—as in the Pelatan-Clerici process, or in the use of the Aurex sluice—to agitation during exposure to the cyanide solution. Furthermore, since in these processes amalgamation and precipitation are carried on nearly simultaneously with solution, not only is the coarse gold quickly removed, but the rusty gold is made capable of amalgamation through being cleansed by the action of the cyanide and the electric current, which are employed simultaneously, while the float gold is either amalgamated directly or dissolved and then precipitated. In these processes the precious metals are recovered as amalgams, which need only retorting and melting to be ready for the mint.

A novel method of overcoming the impermeability of slimes is found in the suggestion of Count von Schwerin,† who proposes to remove water from wet clay and similar amorphous fine slimes by passing through the mass an electric current, whereby the water is driven to the cathode and the solid particles to the anode by "electric endosmosis." The apparatus consists of a wooden vat having for a bottom a brass netting, which forms the cathode; the water being drawn to the netting quickly runs off.

(To be continued.)

There is made and sold each year in this country about $100,000,000 worth of farm machinery. Fully one-half of this goes into the hands of men who do not know how to select it wisely or to keep it in proper condition. The waste which results runs into millions of dollars annually. In addition, implement manufacturers lose large sums in making and attempting to introduce machinery unsuited to the work it is intended to perform, with a resultant loss to both farmers and manufacturers.

---

* Histoire de Chemie, Vol. I, page 226.

† The Metallurgy of Gold, 1896, page 378.

‡ The Art of Electro-Metallurgy, 1877, pages 19 and 20.

§ California State Mining Bureau, Bulletin No. 5, 1894, page 9.

* Journal of the American Chemical Society, 1904, Vol. 26, pages 550 to 555.

† Page 548.

‡ Alfred James, Cyanide Practice, frontispiece, 1902.

* Transactions of the American Institute of Mining Engineers, Vol. XXVI., pages 709 to 721.

† Zeitschrift der Elektrochemie, 1903, page 739.

[Concluded from SUPPLEMENT No. 1543, page 24730.]

ENGLISH MOTOR OMNIBUSES FOR CITY AND COUNTRY USE.

By Our ENGLISH CORRESPONDENT.

A FEW months ago the London Road Car Company, one of the largest omnibus concerns in the English metropolis, which is converting its service to motor traction, acquired a Straker-Squire double-deck omnibus and this stage has now completed its first 10,000 miles without any mechanical difficulties whatever. The four-cylinder motor has cylinders of 105-millimeter (4.133-inch) bore by 105-millimeter stroke, and develops 24 brake horse-power at 900 revolutions per minute normal speed. The valves are mechanically operated and are interchangeable. The main features of the engine are the placing of the lay shaft actuating the valves and the ignition tappets at the top of the cylinders, so that the inlet and exhaust valves can be placed at opposite sides of the cylinders and yet be both operated from the same shaft. This practice has the further additional advantages that it removes all the actuating gear away from the dust and dirt to a place where it is more protected and readily accessible, leaving the crank case free for the introduction of doors through which adjustments can be easily made to the crankshaft bearings, and large ends. The whole of the valve gear can be removed by the withdrawal of a few bolts.

The speed of the engine is regulated by a governor acting direct on the throttle which is also controlled by a pedal from the dashboard, giving speeds ranging from 200 to 900 revolutions per minute. This constitutes the only control, and is quite simple. Cooling is effected by pump circulation and radiator.

A supply of gasoline sufficient for a day's work of ten hours is carried in a tank beneath the driver's seat and the feed therefrom to the vaporizer is by gravity. The frame is of channel steel, rigidly braced, and a spring radius rod is attached to the back axle to take up all shocks and strains.

The vehicle, with a load of thirty-four passengers, has a maximum speed of 16 miles per hour on the level and is capable of ascending a gradient of 1 in 6 under loaded conditions. The running costs of this vehicle have been reduced to as low as 14 cents per mile, including depreciation and renewals. A lower running cost than this has not yet been obtained upon any electric trolley car system. A special 2,000-mile running test was recently carried out under the ægis of the Automobile Club of Great Britain with this omnibus. It was loaded with 75 per cent of its maximum load. Unfortunately, however, the weather was most unpropitious, rendering the roads heavy and sodden, so that the runs were made under adverse conditions. A daily run of 100 miles was made in various parts of the country for 20 consecutive days (Sundays excepted) at an average speed of 12 miles per hour. On 16 days out of the total, the 100 miles were covered without a single involuntary stop, and 1,033 miles were covered without any but a scheduled stop. During the trial 298 gallons of gasoline were consumed and the 200 miles were covered in 167 hours, giving an average of 6.71 miles per gallon at 12 miles per hour. The gross weight of the stage was 5 tons, so that the gasoline consumption was 33.5 ton miles per gallon or 0.03 gallon per gross mile.

STRAKER-SQUIRE DOUBLE-DECK VEHICLE. FOUR-CYLINDER, 24 BRAKE-HORSE-POWER. SEATING CAPACITY, 34 PASSENGERS.

The total running cost of this vehicle is as low as fourteen cents per mile run. A similar vehicle to the above has run over 10,000 miles in London without a mechanical stoppage.

The actual operation of a Straker-Squire motor omnibus by the London Road Car Company is even more striking. The vehicle was installed on the service on March 9 last, and by the 31st of the same month 2,007 miles were covered. For the first ten days the daily run was 72 miles, excepting Sundays, and then it was increased to 117 miles per diem. During this time it made 224 journeys out of a possible 225, the solitary miss being due to a stop for adjusting the brakes. The running expenses for the month were as follows:

Gasoline, 296 gallons	$ 36.75
Lubricating oil, 18 gallons	6.00
Driver's wages	64.50
Cleaning	5.75
Repairs	*nil*
Total for month	$113.00

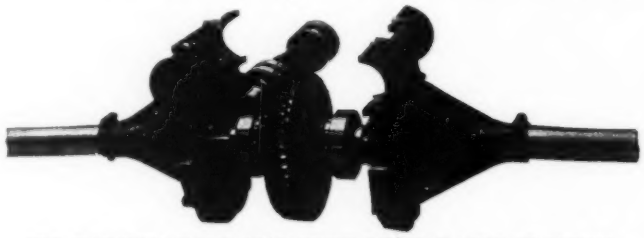
—an average running cost of 5.63 cents per mile.

During April 3,217 miles were covered. Out of 365 maximum journeys 7½ were missed—4 to replace broken tire, 2 for voluntary inspection, 1 to clean magneto ignition, and ½ journey owing to running out of gasoline. The daily run was 117 miles, except Sundays. The result of the month's working was as follows:

Gasoline, 468 gallons	$ 57.50
Lubricating oil	7.25
Wages	90.75
Cleaning	7.50
Repairs	*nil*
Total	$163.00

—an average running cost, 4.60 cents per mile.

During May the omnibus had a complete record. No journeys were missed, 393 being run and a total mileage of 3,537 miles made. The daily run was 117 miles for 27 days. The remaining four days were Sundays, the runs upon which were 81, 99, 99, and 99 respectively. The running expenses during May were:



THE INGENIOUS WORM GEAR DRIVE ON REAR AXLE OF DENNIS 28-HORSE-POWER FOUR-CYLINDER VEHICLE.

Gasoline, 505 gallons	$ 62.66
Lubricating oil	10.98
Wages	97.50
Cleaning	7.75
Repairs	*nil*
Total	$178.89

—average 5.05 cents per mile.

DENNIS FOUR-CYLINDER 28-BRAKE-HORSE-POWER OMNIBUS RUNNING BETWEEN KEW BRIDGE AND SURBITON.

ENGLISH MOTOR OMNIBUSES FOR CITY AND COUNTRY USE.

The engine speed is transmitted to the rear driving wheels through a change-speed gear box and a terminal chain drive giving four speeds forward and reverse. The steering is of the Ackermann type. Ample brakes are fitted of great power, both pedal and hand.

The running of this vehicle constitutes a record, since it ran 84 consecutive days, covering 8,761 miles, without a single stoppage through failure of the mechanism, while the engine ran daily for 17 and 18 hours continuously. The capital charge entailed by purchasing a vehicle of this type is $4,400, the chassis representing $3,250; tires, 5-inch tread with twin rear tires, $475; and double-deck body seating thirty-four passengers, $675.

The London and Suburban Omnibus Company have introduced motor traction upon their route extending from Surbiton to Kew Bridge, and in this case the service is in direct competition with the electric trolley car service. The vehicle selected in this case is the double-deck Dennis power omnibus, which possesses several interesting features, the most important of which is the worm drive to the rear axle and wheels.

The motor is of the inclosed vertical type and has four cylinders of 4.2-inch bore by 5.6-inch stroke, developing 24 horse-power at 900 revolutions per minute, with acceleration to 28 horse-power. The change-speed gives three speeds forward and reverse, with direct drive on top speed. The changing of speeds is controlled from a sliding rod to which is affixed a fork-shaped sliding arm operating on the sliding gear. The second shaft, on which the gearing wheels are fixed, is a steel bushed sleeve revolving round a stationary spindle with internal bearings, automatically lubricated by oil lifts. This principle supports the gears, insuring quieter running and greater durability.

The Dennis spring drive is employed, in which the power is transmitted through four coil springs. This arrangement has the advantage of allowing the vehicle to be started on the top speed on the level, takes off any harshness of the clutch, relieves the gears, and facilitates changing the speeds. The worm drive to the rear axle is the prominent feature of this vehicle. It has proved highly successful in all types of automobiles, having stood the tests of thousands of miles

with entire satisfaction. It is a perfectly silent and simple drive, and highly efficient. This efficiency is equally displayed whether the worm pinion is driving the worm wheel, or the worm wheel is driving the pinion. There is not the slightest tendency toward irreversibility. It will be seen from the accompanying illustration, the worm pinion is contained in a specially constructed differential gear box, and runs on each end on efficient journal and thrust bearings. The worm wheel encircles the differential gear, which is of the parallel-pinion type, with six pinions and two star pinions. The rear axle casing is a malleable casting with specially strengthened outer flanges into which are screwed and locked the live axle casings. The latter extend and take the bearing of the road wheels which take up the drive through driving caps engaging with the square end of the live axle and fitted into recesses on the rear hubs. It will be observed by this system that the wheels have an independent bearing on which to support the weight of the vehicle and passengers, and the live axle has to transmit the drive only. The feature of this system is its simplicity and great durability, a life of several years being possible with ordinary usage.

The artillery wheels are also of special design. The spokes diverge from each other where they leave the hub and enter the felloes anglewise, a principle which insures great lateral rigidity and strength. The wheels are shod with 3½-inch solid tires with twin tires on rear wheels. The front axle is also of special design. It is formed of a forging, and the arms which carry the swivels are fitted with hardened steel cups top and bottom, in which the steering center rotates. The bottom cup is made adjustable to take up any play and is locked by a set-screw. The point of advantage is the absence of pins running through the centers that considerably weaken the ordinary axle. Worm and segment steering is adopted. Water circulation with pump and radiator is employed. The gasoline tank carries 12 gallons of fuel, but provision is made for a further supply of 6 gallons. The total weight of the vehicle is 3 tons, and the price, ready for the road, $4,250.

The worm-drive system to the rear axle has proved one of the greatest improvements that has been effected in motor-propelled vehicles. The car is to all intents and purposes of the live-axle type, but this ingenious arrangement, while possessing all the good qualities of that principle, is free from all its inherent defects.

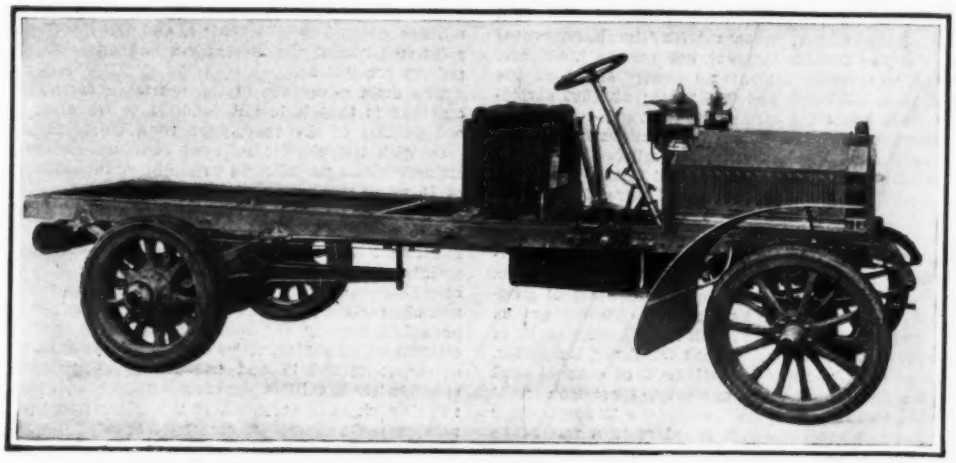
The running expenses with the Dennis omnibus per daily run of 100 miles at 12 to 14 miles per hour with load of thirty-four passengers averages:

Gasoline, 6 miles per gallon	$ 2.77
Lubricating oil	.52
Depreciation and repairs	2.40
Tires (four sets per annum at $30 per tire)	2.30
Insurance	.22
Interest on capital outlay of $4,250	.64
Driver's wages	1.45
Conductor's wages	1.40
Cost of day's run of 100 miles	$11.30

—representing the cost of carrying thirty-four passengers per mile for 11.3 cents.

Great success has attended the utilization of the Thornycroft motor-propelled omnibus both in London and other parts of the country. This manufacturing firm is exploiting both systems of motor power—internal-combustion engines and steam. The gasoline motor, however, is the most popular and convenient for all-round passenger working. The engines are of great power, the four cylinders developing with a 4½-inch bore by 5-inch stroke at 900 revolutions per minute 24 horse-power. Cooling is on general lines by means of pump, radiators, and fan. The frame is of channel steel with a wheel base of 20 feet 4½ inches in length and over-all width of 6 feet 10 inches. It is cambered in front to give a wide lock on the steering wheels.

The drive is transmitted from the engine through a Hele-Shaw clutch inclosed in an oil-tight case, and is connected to the revolving main shaft of the gear by a universal joint. The gear box is fitted with four speeds forward and a reverse. A novel feature of this vehicle is the system adopted for transmitting the speed from the gear to the rear driving wheels. The transmission is through a chain, but instead of a chain running on sprockets on either end of a countershaft, there is a single roller chain of great strength placed almost centrally on the rear axle, which is thus a live one. The longitudinal rotation of the driving shaft is transmitted by bevel gearing to transverse rotary motion. The mechanism is so constructed that there is great flexibility. The result is that all vibration, oscillation, or shock caused by traveling over uneven roads is taken up by the driving sprocket, and does not affect in any way either the gear or the engine. The rear axle is mounted above the semi-elliptical springs and has bumper springs above.



CHASSIS OF FOUR-CYLINDER 28-BRAKE-HORSE-POWER DENNIS DOUBLE-DECK OMNIBUS.

A few months ago Messrs. Thornycroft, Ltd., initiated an interurban motor omnibus service of their own, and from the results of this a conclusive idea of the running cost and maintenance of the vehicles has been obtained, of which we give a brief summary:

Sixteen-Seated Single-Deck Omnibus.
(Average speed 10 miles per hour.)

	Per Annum.
Tires at 4 cents per mile	$960
Gasoline	560
Lubricating oil, etc.	260
Driver's wages	520
Conductor's wages	455
Repairs, depreciation, renewals, etc.	800
Insurance	200
Total running expenses	$3,755

Miles run, 23,040.

Average running cost, 16.39 cents per mile.

Thirty-Four-Seated Double-Deck Motor Omnibus.
(Average speed 10 miles an hour.)

	Per Annum.
Tires	$960
Gasoline	675
Lubricating oil, etc.	450
Driver's wages	520
Conductor's wages	455
Repairs, depreciation, renewals, etc.	1,000
Insurance	250
Total running expenses	$4,210

Miles run, 23,040.

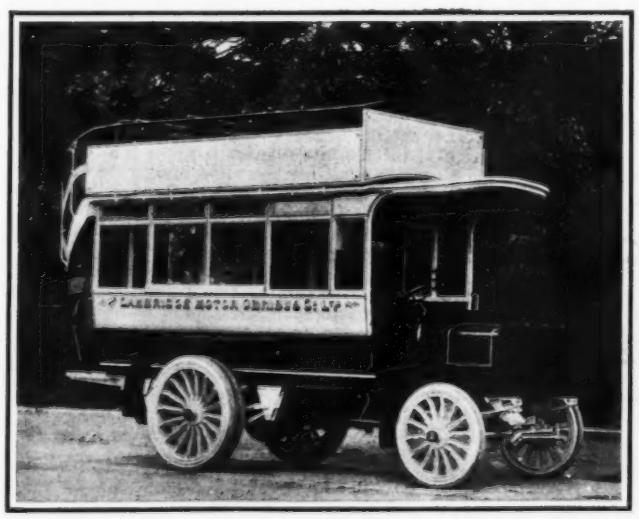
Average running cost per mile, 18.70 cents.

It will be recognized that the running cost of a double-decked vehicle, of more than double passenger capacity, is but little in excess of that entailed in the running of the single-decked type, showing the greater profit attending the employment of the double-deck type.

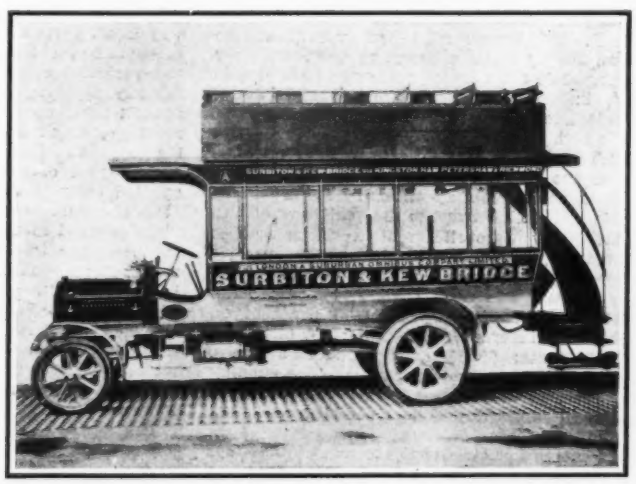
Several leading omnibus companies have adopted the Leyland-Crossley vehicle for their respective systems. This is a double-decked stage carrying thirty-six passengers, and it possesses several interesting features. The four-cylinder motor with a 4¼-inch bore by 5⅛-inch stroke is set to run at a normal speed of 800 revolutions per minute, at which it develops 22 horse-power, but is capable of acceleration up to 1,250 turns per minute. At 1,000 revolutions per minute, 30 brake horse-power is developed, but the speed can be reduced to 200 revolutions per minute, showing great flexibility in engine power. Both the inlet and exhaust valves are mechanically operated and worked by separate cam shafts, which rotate in special oil-tight cam-shaft chambers, the cams thus rotating in an oil bath. The induction valves are of nickel steel, and designed both in area and lift to allow for an air or gas velocity in proportion to the area of the cylinders. The exhaust valves are made of a special hard bronze alloy.

The vaporizer is entirely novel and absolutely automatic in its action. It is of the float-feed type as regards the supply of the gasoline. The air regulation is, however, its special and novel feature. This consists of a float resting on mercury which is coupled with a light rod to a piston valve covering slots in a concentric cover. The mercury chamber consists of two parts concentric with one another but communicating at the base. The inner chamber containing the float is air-tight, but the outer one is open to the atmosphere. From the inner chamber a tube is run to the suction pipe or vaporizing chamber. As the vacuum or depression in the suction pipe or vaporizing chamber is increased, a corresponding depression or vacuum is induced in the mercury chamber. The mercury therefore rises, and the float with it, thus the auxiliary air supply is automatically regulated, simply by means of the engine's own suction, and without the employment of any springs, water pressure, exhaust pressure, or other extraneous means, such as are employed with other so-called automatic vaporizers. This vaporizer gives the motor a great variation of speed and insures absolute quietness of running under all conditions, and great economy in fuel.

The main frame is of channel steel, having a depth of 4¼ by 2½ inches wide. The spring hanger brackets are securely attached thereto, as are also the motor and gear box. The gearing is of the Leyland type, having all wheels in mesh. The wheels are of large diameter, with broad face. The distinguishing feature of the gear is the automatic engaging of the slow-speed gear, which, when changing over, should



20-HORSE-POWER, FOUR-CYLINDER, SINGLE-CHAIN-DRIVE, DOUBLE-DECKED THORNYCROFT OMNIBUS. SEATING CAPACITY, 34 PASSENGERS.



THE LANCASHIRE LEYLAND-CROSSLEY DOUBLE-DECKED MOTOR OMNIBUS.

ENGLISH MOTOR OMNIBUSES FOR CITY AND COUNTRY USE.

the driver miss his gear, the slow speed comes into gear automatically and prevents the vehicle running back. The arrangement of gears is such as to make it impossible for the driver to get two speeds into gear at the same time. Three speeds forward are provided, and a reverse. The Leyland spherical thrust block supports the propeller shaft, and takes the thrust direct to the frame, also making a perfect three-point support to the back axle and allowing for traveling over uneven roads without straining the engine, gearing, or framework. On the end of the propeller shaft is a bevel pinion which engages with the bevel wheel bolted to the differential gear box on the hind axle. The gear gives the following speeds: Motor at 800 revolutions, 10.75, 6.5, and 3.25 miles; at 1,000 revolutions, 13.3, 8.3 and 4 miles per hour. The fuel tank carries 20 gallons and the average fuel consumption is 6 miles per gallon—2.33 cents per mile.

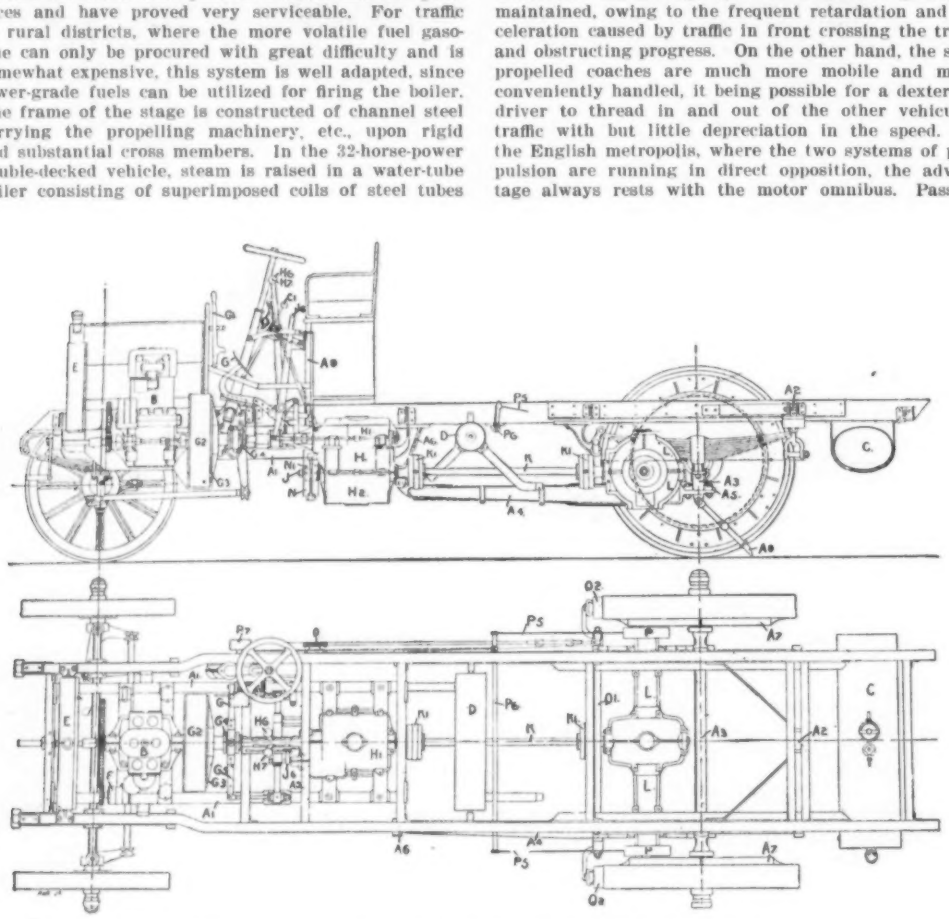
The only firm which has remained faithful to steam as the motive power for its type of self-propelled omnibus is Messrs. Clarkson & Co., of Chelmsford, Essex. Several of these Chelmsford vehicles have been in service for some time past in London and the provinces and have proved very serviceable. For traffic in rural districts, where the more volatile fuel gasoline can only be procured with great difficulty and is somewhat expensive, this system is well adapted, since lower-grade fuels can be utilized for firing the boiler. The frame of the stage is constructed of channel steel carrying the propelling machinery, etc., upon rigid and substantial cross members. In the 32-horse-power double-decked vehicle, steam is raised in a water-tube boiler consisting of superimposed coils of steel tubes welded into plates in such a way that all possibility of leakage is completely obviated. Any grade of paraffin oil can be burned with the Clarkson burner. The steam pressure automatically regulates the size of the flame. The boilers are tested hydraulically to 800 pounds, and by steam pressure to 450 pounds per square inch, while the working pressure is 250 pounds per square inch. After leaving the boiler the steam is superheated to 750 deg. C. The engine consists of two double high-pressure cylinders of 4-inch bore and stroke, with Joy's valve gearing. The power is transmitted from the engine by spur gearing to the differential, and thence to the road wheels by the usual side roller chains. In other respects the vehicle resembles the ordinary gasoline-propelled vehicle. These coaches have proved very economical in running, the various expenses per mile averaging as follows: Fuel, 2.78 cents; lubrication, 0.32 cent; tires, 3.44 cents; maintenance, 3.22 cents; depreciation at 15 per cent on cost, 2.32 cents; insurance, 1.52 cents; establishment charges, 2.14 cents; driver's and conductor's wages, 2.06 cents; total, 17.80 cents per mile. The running cost of a sixteen-passenger omnibus of this type per daily run of 100 miles for 280 days per year works out at 14.34 cents per mile.

The advocates of electric trolley cars maintain that the heavy expenses incurred in connection with the rubber tires, together with the frequency with which the working parts of the motors will have to be renewed, militates against the extensive employment of this system for passenger traffic. Results so far obtained show these contentions to be in every way fallacious. The Straker-Squire power omnibus, which has covered nearly 12,000 miles running in London streets, was recently examined to discover the effect of wear and tear upon the mechanism by driving through the difficult and thickly congested metropolitan streets. Very little wear was observed. Certain re-bushing was considered expedient, as well as the replacement of two speed rings, but the total outlay in respect of renewals did not exceed $50. Compared with the electric trolley cars, this was but a modest sum for renewals, especially when considering the mileage covered by the vehicle, and the fact that the rotating parts of the mechanism had made over fifty million revolutions.

The main advantage of the operation of the motor omnibus is that it is not confined to traveling upon one portion of the road, such as a track, as is the case with the electric railroad cars. In London the latter vehicles are allowed to attain a maximum speed of 10 miles per hour, but it is very seldom that such an average speed can be maintained, except in those hours when the ordinary vehicular traffic is at its minimum. An average speed of 6 miles is generally maintained, owing to the frequent retardation and acceleration caused by traffic in front crossing the track and obstructing progress. On the other hand, the self-propelled coaches are much more mobile and more conveniently handled, it being possible for a dexterous driver to thread in and out of the other vehicular traffic with but little depreciation in the speed. In the English metropolis, where the two systems of propulsion are running in direct opposition, the advantage always rests with the motor omnibus. Passengers have discovered that the latter vehicle will cover the distance between two points in much less time than the restricted electric vehicle.

Motor-omnibus development is making great headway in all parts of the country. That it is a serious factor to be reckoned with is shown from the fact that the various electrical railroad authorities are determinedly opposing the introduction of motor services coming into opposition with their interests. Government protection is even being sought in certain instances, but so far has been attended with no response on the part of the authorities, who recognize that spirited competition in transit only conduces to the general public benefit. The factories of the various firms engaged in the exploitation of motor omnibuses for passenger traffic have their output bespoken for many months ahead. Even the railroad companies have realized its potency as a solution of the problem of providing efficient communication between the thinly populated rural districts where a railroad would fail to be a financial success, and are utilizing the motor vehicle as an efficient feeder to their respective trunk systems by collecting and distributing both passengers and freight over wide areas.

The diagrams shown herewith are a side elevation and plan of a standard Milnes-Daimler chassis, such as was described in our last issue, the only difference being that the 20-horse-power bus is provided with a four-cylinder motor having 4⅛ by 5⅛-inch cylinders instead of with a two-cylinder engine, as here shown. The shaft drive and consequent dispensing with chains is one of the features of this vehicle.



SIDE ELEVATION AND PLAN OF MILNES DAIMLER 3-TON CHASSIS.

A_1. Sub-frame carrying motor and transmission gear. A_3. Transverse spring at rear of chassis. A_5. Cross brace of main chassis. A_4. Armored wood radius rods. A_6. Rear axle. A_8. Bracket for supporting gear box. A_7. Internal gear ring for driving rear wheel. A_9. Sprags for holding vehicle on a hill. B. Gasoline motor. C. Gasoline tank. D. Muffler. E. Honeycomb radiator. F. Magneto. G. Clutch and brake pedal. G_1. Locking lever for G. G_2. Flywheel. G_3. Clutch cone. G_4. Clutch shipper. G_5. Pivoted lever engaging G_4. H. Gear box. H_1, H_2. Top and bottom of gear box. H_3. Lever for first and second speeds. H_2. Lever for third and fourth speeds. J. Lower, or driven, shaft of transmission. J_3. Reverse lever. K. Longitudinal driving or propeller shaft. K_1. Universal joints of same. L. Countershaft. N. Brake on transmission shaft. P. Brakes on differential countershaft. P_5. Wires for operating countershaft brakes. P_6. Hollow rod through which wires connect. P_7. Pedal for countershaft brakes. Q. Lever for brakes on rear wheel tires. Q_1. Cross rod carrying brake levers. Q_2. Brake shoes.

ENGLISH MOTOR OMNIBUSES FOR CITY AND COUNTRY USE.

IMPROVING GAS ENGINE EFFICIENCY.

Were gas-power engineers more accustomed to work out indicator diagrams from the basis of the absolute vacuum instead of from the atmospheric line, it is probable that better results might be secured. Another road that might lead to economy would be the practice of taking diagrams with a weak spring and a stop on the movement of the piston, in order to obtain a clear picture of the processes inside the cylinder within, say, 15 pounds of the atmospheric line. As a rule, with a diagram scale suitable for pressures of 300, or even 500, pounds per square inch, the scale is so minute that nothing can be read off clearly up to more than 20 pounds above the atmosphere. The line drawn by the blunted style may very easily cover a breadth of 10 pounds pressure.

A thermometer in the exhaust pipe close to the engine will greatly help to a clear idea of some of the losses of a gas engine. The ordinary atmospheric or intake temperature is 520 deg. F. absolute. Let us suppose, for convenience of calculation, that the exhaust temperature is 1,040 deg. F. absolute (547 deg. F.). The volume of the exhaust will then be practically double the volume of the intake. That is to say, for each cubic foot of cylinder capacity there will be 2 cubic feet of exhaust volume, or 1 cubic foot of gas in excess of the intake volume must be forced into the atmosphere. The atmospheric pressure is 2,117 pounds per square foot, or the work done in forcing 1 cubic foot into the atmosphere is 2,117 foot-pounds. At the ordinary speed of 80 explosive strokes per minute, there will be 161,344 foot-pounds of energy thus wasted per minute, or nearly 5 horse-power.

Now, a gas engine of 1 cubic foot cylinder-stroke volume, if it secured a mean pressure of 60 pounds, would generate nearly 21 horse-power. If the same engine could be made to exhaust into, or, rather, through, a large ice-cold surface condenser, it would generate 25 to 26 horse-power. The steam engine secures an economy from condensing, not because the condenser and air pump remove the atmospheric pressure, for they do not. The final exhaust of the steam engine is pushed into the atmosphere, but it is not pushed in until it has shrunk to a small volume; usually it has shrunk to liquid volume, and it does not require to displace a large volume of the atmosphere. In the gas engine there is no intentional condenser. Long exhaust pipes have been employed, the explanation given of their benefit being that the energy of the moving column of gas in the pipe exerts a pull upon the engine piston. This is not a satisfactory explanation, and the benefit, if any, would only be secured by the use of a gradually tapering pipe, so as to allow the gas to finish at a lower velocity. But probably the true cause of the gain is the cooling effect of the long pipe. The volume of gas is reduced, and there is less displacement of the atmosphere. Thus, in the case assumed, a reduction of the gas temperature of about 260 deg. F. would reduce the expulsion effort by one-half, or nearly 2½ horse-power. It would add a clear 10 per cent to the power of the engine.

There must be many cases where the exhaust of a gas engine could be cooled between the cylinder and the point of entry into the atmosphere without serious obstruction of the flow of the gas. The effect of such cooling would be shown clearly upon the enlarged scale indicator diagram. With hydrogenous gas the exhaust is largely steam, which would practically disappear with a really cold condenser. A gas engine condenser should be cheap to make: its internal pressure would always be higher than that of the atmosphere, so that tightness would be of no material account. Its use is the same as that of the steam engine condenser—namely, to reduce the volume of the exhaust gas, and therefore the work done in pushing aside the atmosphere. The doing of this work manifests itself as increased back pressure on the piston, but the fine scale of the diagram has prevented this from being sufficiently appreciated.—Electrical Review (London).

TEST OF A STEAM TURBINE AFTER TWO YEARS' SERVICE.

There has been quite a discussion of late in the technical papers in regard to the probable deterioration of steam turbines after having been in actual service a number of years, and the effect of service on the steam economy of the machine. On account of the comparatively recent introduction of the steam turbine into this country, the information in this line has been more or less meager, although this is not the case in Europe, and accordingly the results obtained by Prof. Edward F. Miller and R. R. Lawrence, of the Massachusetts Institute of Technology, in tests made recently on a 150-horse-power steam turbine dynamo set, which has been in service at the New England Structural Company for the past two years, will be of interest.

Shortly before the test was made the turbine was taken apart and thoroughly examined as regards wear, etc., photographs being taken of the turbine wheel, buckets and pinion, and by examining them it was noted that the wear on all these parts was practically *nil*. The owners of the plant have also written as follows on this subject:

"We beg to advise you that the two steam turbine generators purchased of you about two years ago have proved very satisfactory in every way. The wheel and pinion, of which photographs have been taken, have been in constant operation for over a year and a half, and there is no trace of wear appreciable on the pinion or the buckets. In fact, many of the latter still

have some part of the original scale made during the process of drop forging."

This machine is one of a pair which were built by the De Laval Steam Turbine Company at its Trenton, N. J., shops, in the spring of 1903, both machines having been constantly in service at the New England Structural Company, East Everett, Mass., for furnishing power and light for its entire plant.

These machines were ordered under the following steam guarantees: With 150 pounds steam pressure at governor valve and 26-inch vacuum at the turbine; 18.7 pounds of steam per brake-horse-power per hour at full load, and 19.7 pounds at half load. By comparing these figures with those just obtained by Profs. Miller and Lawrence, it will be noted that the turbines are still well within their original guarantees, thus proving that the deterioration, if any, has apparently not affected the steam consumption.

The test took place June 11, last, starting at 9 A. M. and finishing at 6 P. M., after which the electrical heat losses were obtained in order to determine the absolute brake-horse-power. The steam supplied to the turbine under test came from one boiler. Steam for the auxiliaries and for the feed pump supplying this boiler came from a second boiler. All condensation in the steam main leading to the turbine was returned to the boiler by means of a steam loop.

The steam used was determined by weighing the feed water put into the boiler. The level in the boiler was kept nearly constant during the test, and was made the same at the end as at the beginning.

The blowoff pipe and the auxiliary feed pipe were disconnected and banked. All the piping, both steam and feed, was kept tight, and there were no leakages to make allowance for, all the water put into the boiler being used in the turbine and in the calorimeter.

The feed water was weighed in a barrel on a pair of scales sensitive to less than one-quarter of a pound under maximum load. The water weighed was run into a small barrel beneath the scales. The feed pump pumped from this barrel to the boiler. It is probable that the water weight is correct to less than 25 pounds in the total.

The quality of the steam was figured from readings taken on a throttling calorimeter placed near the throttle of the turbine. The time the calorimeter was in use was noted and the amount of steam used by it was calculated by Napier's formula. The orifice used to do the throttling was ¼ inch in diameter.

Pressures were taken at the throttle and in the case supplying the nozzles. This latter pressure is beyond the governor, and fluctuates with any change of load. Temperatures of the steam at these two places were taken also. It was thought that the throttling by the governor might dry out any slight amount of moisture in the steam, and that the steam entering the nozzles might be slightly superheated. During this test the throttling was slight; and there was but little change in the quality of the steam in passing through the governor valve.

The vacuum was measured by a U-tube filled with mercury. The poorer vacuum obtained near the middle of the test was due to low water in the river.

The electrical output was taken up in a water cooled resistance. The necessary electrical instruments were inserted for the measurement of the power. The load was very steady throughout the test.

Previous to starting on the test, the turbine had been running 45 minutes. Turbine ran with but little noise.

TEST OF DE LAVAL TURBINE.

Duration of test, hours	9
Boiler pressure gage, lb.	152.9
Boiler pressure below governor valve, lb.	145.9
Number of nozzles in use	6
Quality of steam, priming, per cent.	1.05
Barometer, in.	29.90
Vacuum, in.	25.47
Average volts, dynamo No. 1	262.7
Average volts, dynamo No. 2	262.1
Total amperes	202.0
Average total kw. output	106.1
Average total E. H. P. output	142.2
Average total B. H. P. input	160.4
Average number of revolutions per minute	1,200.0
Total steam used for nine hours, lb.	25,661
Average steam per hour, lb.	2,851.0
Average steam per hour, corrected for moisture, lb.	2,826.0
Steam per kw.-hour, lb.	26.49
Steam per E. H. P.-hour, lb.	20.05
Steam per B. H. P.-hour, lb.	17.77
Steam per B. H. P.-hour, corrected for moisture, lb.	17.62

The electrical instruments were all calibrated before and after the test, by Prof. F. A. Laws, also of the Massachusetts Institute of Technology.—The Engineering Record.

ETHER DRIFT.

THE question as to whether or not the earth carries the ether near it in its journey through space is one of very great theoretical importance, and the last word upon it has not yet been said. The fact that stellar aberration has the same value whether determined by means of an ordinary telescope or by one filled with water can most simply be explained by supposing that in the water the ether is carried forward with a portion only of the earth's velocity, while in the air round the telescope it is sensibly at rest in space.

On the other hand, the results of Michelson's and Morley's experiments with their interferometer can be accounted for most simply by supposing that both the earth and the ether near it are moving with the same speed—that is to say, that the earth drags the surrounding ether with it in much the same way as that by which a layer of air is carried by a projectile.

Experiments by Sir O. Lodge on whirling massive disks prove that they, at any rate, exert no perceptible drag; and consequently if the earth does so it must be due to its great magnitude. It was pointed out by FitzGerald (and independently by Lorentz) that if we suppose that the length of a body when set moving is shortened in the direction of that motion, then Michelson and Morley's experiments do not imply the absence of relative motion; in fact, if the shortening takes place to an appropriate extent, they do not show that the ether is moved at all. Other experiments have also been made which seem to require that this supposed shortening is real.

Morley has recently (Philosophical Magazine, May, 1905) varied his previous investigation with the object of testing whether the compensation which cancels the effect due to relative motion is complete in every case. It is the shrinkage of the base-plate of his apparatus which may come into play; and, besides improving the apparatus by increasing the sensitiveness, he has changed the material of this plate from iron to wood. There is still absence of any indication of relative motion of earth and ether, and the proportional shortening must therefore be the same as in the previous experiments.

It may at first sight seem unlikely that two such different materials should be equally affected. But the true explanation must be that it is not the nature of the molecule (or molecular aggregate) or even that of the chemical atom which determines it; for these are very different in the two cases. It is something more fine grained than these, and this something must be essentially identical (at any rate, as far as this particular property goes) in both these bodies. In fact, the result is an additional piece of evidence in favor of the theory that all atoms are built up of smaller particles, each one of which is of the same kind.—Alfred W. Porter, B.Sc., in Knowledge and Scientific News.

CURIOUS HABITS OF WASPS.

IN all natural history there are, perhaps, no more fascinating and extraordinary chapters than those which deal with the habits of ants, bees, and wasps, writes Lord Avebury in the London Chronicle. When we speak of bees and wasps we generally think of the social species. These, however, are comparatively few in number, while the solitary forms are much more numerous, and scarcely, if at all, less interesting.

We owe to M. Fabre, the distinguished French entomologist, a most interesting and delightful series of observations on the habits of insects. Some of the most striking are those in which he describes the solitary bees and wasps. Speaking generally, we may say that each female constructs a cell, every species having its own favorite site. She then stores up in it a sufficient supply of food, which, in the case of bees, consists of pollen and honey, while wasps select small animals, such as beetles, caterpillars, spiders, etc. The mother then lays an egg, after which she closes up the cell and begins another. Generally, though not invariably, she takes no further notice of her offspring.

Many years ago M. Fabre published some careful and brilliant observations on the subject. He found that some wasps sting their victims in such a manner as to paralyze, but not to kill them; and he argued that this remarkable instinct must have been original, and could not have been gradually acquired, since, if the caterpillar were uninjured, it would struggle to escape, and almost inevitably destroy the egg of the wasp; or, if it were killed, it would decay, and soon become unfit for food.

Many years ago I suggested that the facts did not bear out M. Fabre's conclusions; that instincts were by no means so invariable as he assumed; that even in this case some wasps buried their victims but little injured, some more or less paralyzed, and others killed outright, without harm being done to the young wasp. Striking support of this view is now given by Mr. and Mrs. Peckham, who confirm the statement that the victims are by no means always treated in the same manner.

One of the important results of their investigations consists in the additional evidence which they have collected of the great diversity of habits, not only between different species but also between different individuals belonging to the same species. Prof. Forel and I both arrived at similar results in the case of ants, and, as Mr. and Mrs. Peckham point out, it is exceedingly probable that a painstaking study of any branch whatever of the animal kingdom would lead to the same conclusion. They tell us that they found "a most interesting variation among the different individuals, not only in methods, but in character and intellect. While one [wasp] was beguiled from her hunting by every blossom she passed, another stuck to her work with indefatigable perseverance. While one stung her caterpillar so carelessly and made her nest in so shiftless a way that her young could survive only through some lucky chance, another devoted herself to these duties not only with conscientious thoroughness, but with an apparent craving after artistic perfection that was touching to see."

An example of such an apparent craving is given in the case of a *Pompilius fuscipennis*, who, having finished the building of her nest, "brought a quantity of small objects and placed them over the nest—a little stick, the petal of a faded flower, a scrap of dead leaf, and so on until ten or twelve things had been collected." This certainly appears to have been entirely personal, since in no other examples of *Pompilius fuscipennis* did they ever see such perfect work again.

Prof. Fabre himself, indeed, shows that instincts are not immutable. For instance, on one occasion he took two dozen solitary bees' cells from a quarry, where they had been nesting, as he supposes, for centuries, in snail shells, and placed them in his study with some empty shells and hollow stems. When the young bees came out, in the following spring, nearly all of them selected the stalks to build in as being better suited to their use than the shells.

One of Mr. and Mrs. Peckham's most interesting observations is that of an *Ammophila urnaria*, that actually took a small pebble in her mandibles and used it as a hammer to pound down the earth over her nest.

Such examples of what may almost be called artistic and intellectual gifts are balanced by many cases of equally surprising carelessness and stupidity. Some absent-minded wasps cheerfully close up their cells, quite forgetting to supply the necessary food, or even to lay an egg; others, when interrupted in their work, appear incapable of picking up the threads again. Yet perhaps we should not be too hasty in judging these poor wasps, when we remember that even men are not invariably intelligent in either what they do or leave undone.

This is not confined to the stupid or vicious; even the ablest often fail to perceive what afterward appears almost self-evident. I may, for instance, refer to the fact that the use and effects of laughing gas were discovered by Sir H. Davy at the commencement of the last century, and taught in the best medical schools for fully fifty years before the apparently obvious idea occurred to any one that these properties might be put to use in actual practice.

Other similar facts might be adduced, and ought to make us chary of accusing these wonderfully industrious little creatures, whose motives it is quite possible we may not always understand. Wasps are even busier than the busy bee. I have several times watched one the whole day, and from four in the morning till light failed in the evening she worked without any interval for rest or enjoyment.

The males of the solitary wasps are not so invariably idle as those of the social species. In some cases they guard the nest during the absence of the female, certainly an important office in protecting the young from parasites. Once, when the work of storing the nest had been delayed by rainy weather, they saw a male *Tryporylon rubrocinctum*, which feeds its young on spiders, "assisting by taking the spiders from the female as she brought them and packing them into the nest, leaving her free to hunt for more."

Nevertheless, wasps seem well aware of the disastrous effects of "all work and no play." Mr. and Mrs. Peckham noticed that *Aporus fasciatus* "seemed to have seasons of leisure alternating with spells of active work, as though, when one cell had been filled up and the egg laid, they felt at liberty to amuse themselves for a time before beginning on another."

One of the most interesting questions connected with the instincts and powers of animals has reference to the manner in which they find their way back, after having been carried to a distance from home. This has by some been attributed to the possession of a special "sense of direction;" but long ago I attempted to prove that this was not so, and Mr. and Mrs. Peckham have come to the same conclusion. Bees and wasps take a good account of their bearings before going far afield, and even then sometimes lose their way.

CONSUMPTION OF HORSEFLESH IN GERMANY.

THE increasing consumption of horseflesh among a large class of people of moderate means in Germany, many of whom eat fresh meat of any kind only on Sundays and holidays, has been specially remarked upon. There is in the Greifswalder Strasse, Berlin, a regularly installed horse slaughter house, which is under careful police supervision with a veterinary surgeon in attendance to see that no animal is killed, the flesh of which, by reason of disease or other cause, would be unfit for human food. In 1895 the whole number of horses killed in Berlin for human consumption was 7,267. In 1900 the number had increased to 10,815, and in 1904 to about 13,000. Estimating that an average sized horse will yield 230 pounds of edible flesh there was derived from this source last year about 2,990,000 pounds of meat, which was sold for consumption in 64 shops which are specially licensed for that purpose. The United States consul-general says that at Breslau, which has a population of about 500,000 against 2,500,000 in Berlin and its suburbs, 3,800 horses were killed last year for human food, so that the proportion of horseflesh eaten per capita was much larger in Breslau than in Berlin. In southern Germany and notably in Saxony, where the percentage of working people in manufacturing districts is exceptionally large, the consumption of horseflesh is still greater, and is constantly increasing. The choicest cuts of horse meat sell in Berlin from fourpence to fivepence per pound. Meat from the forequarters or from any part of poor, old, or inferior horses sells as low as three halfpence and twopence. The liver, however, is considered a delicate morsel, and fetches fivepence a pound. The inferior pieces go into the mill for the manufacture of those strongly-spiced sausages flavored with garlic that are the favorite food of many of the poorer classes in Germany. In the better grade of these sausages pork is mixed, to give the requisite fatness, and when sold for consumption in Berlin they must be plainly labeled

"Pferdefleisch" (horseflesh). Outside the municipality this regulation is, however, not enforced, so that quantities of sausages made of horseflesh, with only a small percentage of pork, veal, or other meat in their composition, are sold to the country districts or exported to the neighboring countries as ordinary pork sausages. The American consul adds that, apart from the very general sentiment of respect for the horse as an animal too noble and useful for the degradation of the slaughter house, there is perhaps no good reason why its flesh is not as clean and nutritious as that of horned cattle, and the fact of its far greater cheapness in a country where all meat is so costly as it is in Germany, makes the well-regulated system of horseflesh preparation and supply in Berlin a real boon to a large class of people.

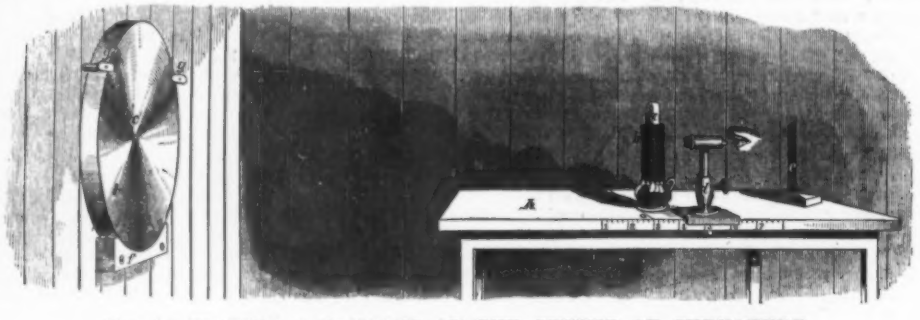


FIG. 8.—TESTING A CONCAVE AT THE CENTER OF CURVATURE.

[Continued from SUPPLEMENT No. 1543, page 24730.]

THE CONSTRUCTION OF A SILVERED GLASS TELESCOPE, FIFTEEN AND A HALF INCHES IN APERTURE, AND ITS USE IN CELESTIAL PHOTOGRAPHY.—II.*

d. Methods of Examining Surfaces.

I HAVE been in the habit of testing mirrors exclusively at the center of curvature, not putting them in the telescope tube until nearly parabolic or finished. The means of trial are so excellent, the indications obtained so precise, and the freedom from atmospheric disturbances so complete, that the greatest facilities are offered for ascertaining the nature of a surface. In addition the observer is entirely independent of day or night, and of the weather. I do not think that anything more is learned of the telescope, even under favorable circumstances, than in the workshop. For the improvement of these methods of observation, science is largely indebted to M. Foucault, whose third test—the second in the next paragraph—is sufficient to afford by itself a large part of the information required in correcting a concave surface.

There are two distinct modes of examination: 1st, observing with an eye-piece the image of an illuminated pin-hole at the focus, and the cone of rays inside and outside that plane; 2d, receiving the entire pencil of light coming from the mirror through the pupil on the retina, and noticing the distribution of light and shade, and the appearances in relief on the face of the mirror.

The arrangements for these tests are as follows:

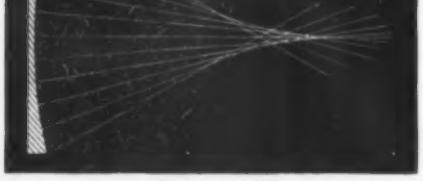


FIG. 10.—CAUSTIC OF OBLATE SPHEROIDAL MIRROR.

Around the flame of a lamp (*a*, Fig. 8) a sheet of tin is bent so as to form a cylindrical screen. Through it at the height of the brightest part of the flame, as at *b*, two holes are bored, a quarter of an inch apart, one 1/32 of an inch in diameter, the other as small as the point of the finest needle will make—perhaps 1/200 of an inch. This apparatus is to be set at the center of curvature of the mirror *c*—the optical axis of the latter being horizontal—and so adjusted that the light which diverges from the illuminated hole in use, may, after impinging on the concave surface of the glass, return to form an image close by the side of the tin screen. In the case of the first test, the returning rays are received into an eye-piece or microscope, *d*, magnifying 20 times, and moving upon a divided scale to and from the mirror. In the second test the eye-piece is removed away from before the eye, and a straight-edged opaque screen, *e*, is put in its place. The mirror is supported in these trials by an arc of wood, *f*, lined with thick woolen stuff, and above two wooden latches, *g g*, prevent it from falling forward, but do not compress it. It is, of course, unsilvered. In the figure the table is represented very much closer to the mirror than it should be. In trials on the 15½ inch it has to be 25 feet distant.

The appearance that a truly spherical concave surface presents with the first test is: the image of the hole is sharply defined without any areola of aberration around it, and is surrounded by interference rings. Inside and outside the focus the cone of rays is exactly similar, and circular in section. It presents no tract of irregular illumination, nor any bright or dark circles. With the second test, when the eye is brought into such a position that it receives the whole pencil of reflected rays, and the opaque screen is gradually drawn across in front of the pupil, the brightness of the surface slowly diminishes, until just as the screen is cutting off the last relic of the cone of rays (Fig. 9), the mirror presents a uniform grayish tint, followed by total darkness, and gives to the eye the sensation of a plane.

FIG. 9.—ACTION OF THE OPAQUE SCREEN.

FIG. 11.—ACTION OF THE OPAQUE SCREEN.

If, however, the mirror is not spherical, but instead gradually decreases in focal length toward the edge, the following changes result: The image at the best focus is surrounded by a nebulosity, stronger as the deviation from the sphere is greater, and neither can a sharp focus be obtained nor interference fringes seen. In order to include this nebulosity in the image, it will be necessary to push the eye-piece toward the mirror. Before the cone of rays has completed its convergence, the mass of light will be seen to have accumulated at the periphery, and after the focus is past and divergence has commenced, the accumulation will be around the axis. That is, a caustic (Fig. 10) is formed with its summit from the mirror. By the second test, in gradually eclipsing the light coming from the mirror, just before all the rays are obstructed, a part of those which have constituted the nebulosity will escape past the screen (Fig. 11) into the eye, and cause there an extremely exaggerated appearance in relief of the solid superposed upon the true surface beneath. The glass will no longer seem to be a plane, but to have a section as in Fig. 12. Let

FIG. 12.—APPARENT SECTION OF OBLATE SPHEROIDAL MIRROR.

us examine by the aid of M. Foucault's diagrams why it is that the surface seems thus curved. If the dotted line, Fig. 13, represents the section of the mirror, and the solid line a section of a spherical mirror of the same mean focal length, it will be seen that the curves touch at two points, but are separated by an interval elsewhere. If this interval be projected by means of the differences of the ordinates, the resulting curve will be found to be the same as that which the mirror apparently has.

If the opaque screen be drawn a short distance from the mirror, the appearance of the section curve will seem to change, the bottom of the groove (Fig. 12) between the center and edge advancing inward, and the mound in the middle growing smaller. If the screen be pushed toward the mirror the reverse takes place, the central mound becoming larger, but the edge decreasing. The reason for these variations becomes apparent by considering the three diagrams, Fig. 14. The dotted curve in each instance represents the real curve of the mirror described in the last paragraph, while the solid lines are circles drawn with radii progressionally shorter in *a*, *b* and *c*, and represent sections of three spherical mirrors whose focal lengths also progressively shorten.

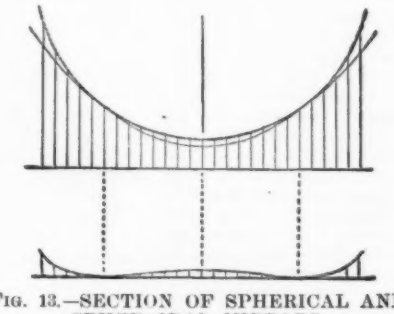


FIG. 13.—SECTION OF SPHERICAL AND SPHEROIDAL MIRRORS.

When the opaque screen is at a given distance from mirror under examination, the only parts of the mirror which can officiate well are those which have a curvature corresponding to a radius equal to the same distance. All the other parts seem as if they were covered by projecting circular masses. In looking at Fig. 14, it is plain, then, if the opaque screen is at a maximum distance from the mirror, that the central parts alone will seem to operate, because the two curves (*a*) only touch there. If the screen is moved toward the mirror, the curves (*b*) will coincide at some point between the center and edge, while if carried still farther in only the edges touch and the appearance will be as if a large mound were fixed upon the center. I have been careful in explaining how a surface may thus seem to present entirely different characteristics if examined from points of view which vary slightly in distance, because a knowledge of these facts is of the utmost importance in correcting such an erroneous figure. It is now obvious that the correction will be equally effectual if the mirror be polished with a small rubber on the edge, or on the center, or partly on each. The only difference in the result will be, that the mean focal length will be increased in the first instance, and decreased in the second, while it will remain unchanged in the third.

FIG. 14.—RELATION OF SPHERES TO OBLATE SPHEROID.

If the mirror, instead of having a section like that of an oblate spheroid, should have either an ellipse, parabola, or hyperbola, as its section curve, the appearances seen above are reversed. While by the first test there is still an aberration round the image at the best focus, the eye-piece must now be drawn from the mirror to include it. The cone of rays is most dense round the axis inside, and at the periphery outside the focus, and the summit of the caustic (Fig. 15) is turned toward the mirror. The second test shows a section as in Fig. 16, a depression at the center, and the edges turned backward. The nature of the movement necessary to reduce the surface to a sphere is very plainly indicated, action on a zone *a* between the center and edge. If, however, a parabolic section is required, the zone *a* must not be entirely removed,

FIG. 15.—CAUSTIC OF HYPERBOLIC MIRROR.

and the surface rendered apparently flat, but as much of it must be left as experience shows to be desirable.

If, in still a fourth instance, the mirror is not formed by the revolution of any regular curve upon its axis, but has upon its surface zones of longer and shorter radius intermixed irregularly, a very common case, the two tests still indicate with precision the parts in fault, and the correction demanded. Thus the mirror seen in section in Fig. 17, when the principal mass of light was obstructed by the opaque screen, would

* Reprinted from Smithsonian Contributions to Knowledge, Vol. xxxiv.

still permit that coming from certain parts to find its way into the eye.

Fig. 18 represents an irregular mirror, that was produced in the process of correction of a hyperbolic surface, which had an apparent section like Fig. 16 previously. The zone *a* had been acted upon with a small local polisher, and the mirror was finished by subsequently softening down *b* and *c* with a larger tool.

After having gained from the preceding paragraphs a general idea of the value and nature of these tests at the center of curvature, a more particular description of their use is desirable. M. Foucault in his methods first brings the mirror to a spherical surface, and then

FIG. 16.—APPARENT SECTION OF HYPERBOLIC MIRROR.

by moving the luminous pin-hole toward the mirror, and correspondingly retracting the eye-piece or opaque screen, carries it, avoiding aberration continually by polishing, through a series of ellipsoidal curvatures, advancing step by step toward the paraboloid of revolution. The length of the apartment, however, soon puts a termination to this gradual system of correction, and he is forced to perform the last steps of the conversion by an empirical process, and eventually to resort to trial in the telescope.

With my mirrors of 150 inches focal length, demanding from the outset a room more than 25 feet long, this successive system had to be abandoned. It was not found feasible to place the lamp in the distant focus of the ellipse—the workshop being less than 30 feet long—and putting the luminous source on

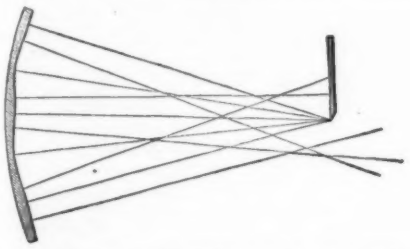


FIG. 17.—ACTION OF THE OPAQUE SCREEN.

stands outside, introduced several injurious complications, not the least of which was currents in the layers of variously refracting air in the apartment. In a still room the density and hygrometric variations in its various parts only give rise to slight embarrassment. The moment, however, that currents are produced, satisfactory examination of a mirror becomes difficult. The air is seen only too easily to move in great spiral convolutions between the mirror and the eye, areolæ of aberration appear around a previously excellent image, and were it not for the second test, any determination of surface would be impossible. By that test the real deviations from truth of figure can be distinguished from the atmospheric, and to a practised eye sufficient indications of necessary changes given. Such a movement as that caused by placing the hand

FIG. 18.—APPARENT SECTION OF MIRROR WITH RINGS.

in or under the line of the converging rays, will completely destroy the beauty of an image, and by the second test give origin in the first case to the appearance, Fig. 19. In order to be completely exempt at all times from aerial difficulties, it is desirable to have control of a long underground apartment, the openings of which can be tightly closed. As no artificial warmth is needed, there is the minimum of movement in the inclosed air, and conclusions respecting a surface may be arrived at in a very short time. The mirror may also be supported from the ground, so that tremulous vibrations which weary the eye, and interfere with the accuracy of criticism, may be avoided.

Driven then from observing an image kept continu-

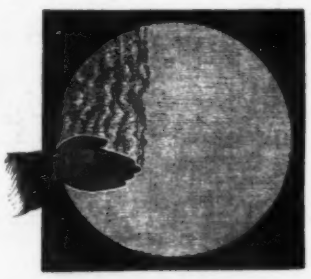


FIG. 19.—ATMOSPHERIC MOTIONS.

ally free from aberration, through advancing ellipsoidal changes, it became necessary to study the gradual increase of deformation, produced by the greater and greater departures from a spherical surface, as the parabola was approached. It was found that a sufficient guide is still provided in these tests, by modifying them properly.

The longitudinal aberration of a mirror of small angular opening is easily calculated—being equal to the square of half the aperture, divided by eight times the

FIG. 20.—ADJUSTING THE OPAQUE SCREEN.

principal focal length. That is, if a 15½-inch mirror of 150 inches focal length were spherical, and were used to converge parallel rays, those from its edge would reach a focus 5-100 of an inch nearer the mirror than those from its central parts. If now the converse experiment be tried, and a mirror of the same size and focal length which can converge parallel rays, falling on all its parts, to one focus, be examined at the center of curvature, it gives there an amount of longitudinal aberration 10-100 of an inch, equal to twice the preceding. This latter, then, is the condition at the center of curvature, to which such mirror must be brought in order to converge parallel rays with exactness. In addition, strict watch must be kept upon the zones intermediate between the center and edge, both by measurement with diaphragms of their aberration, and better yet, by observation of the regularity of the curve of that apparent solid, Fig. 16, seen by the second test.

This modification of the first test is literally a method of parabolizing by measure, and is capable of great precision when the eye learns to estimate where the exact focus of a zone is. The little irregularities found round the edges of the holes through the tin screen, Fig. 8, are in this respect of material assistance. They show, too, the increased optical or pene-

FIG. 23.—LOCAL POLISHER.

trating power that is gained by increase of aperture. Minute peculiarities, not visible under very high powers with a 10-inch diaphragm, become immediately perceptible even with less magnifying when the whole aperture is used, provided the mirror is spherical.

In the use of the second test precautions have to be taken to set the opaque screen exactly in the proper position. The best method for ascertaining its location is, having received the image into the eye, placed purposely too near the mirror, to cause the screen to move across the cone of rays from the right toward the left side. A jet black shadow begins to advance at the same time, and in the same direction across the mirror. If the eye is then moved from the mirror sufficiently, this black shadow can be made to originate by the same motion of the screen as before, from the left or opposite side of the mirror. Midway between these extremes there is a point where the advance is from neither side. This is the true position for the

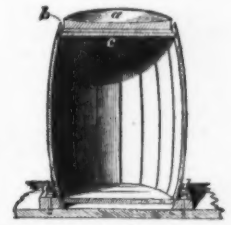


FIG. 24.—SECTION OF OPTICIAN'S POST.

screen when it is desired to see the imperfections of the surface in highly exaggerated relief, as in Fig. 20, which represents the appearance of Fig. 12.*

The interpretation of the lights and shadows upon the face of a mirror in this test is always easy, and the observer is not likely to mistake an elevation for a depression, if he bears in mind the fact that the surface under examination must always be regarded as illuminated by an opaque light coming from a source on the side opposite to that from which the screen advances, coming for instance from the left hand side, in the above description.

In practice, the diaphragms commonly used for a 15½-inch mirror have been as small as the light from

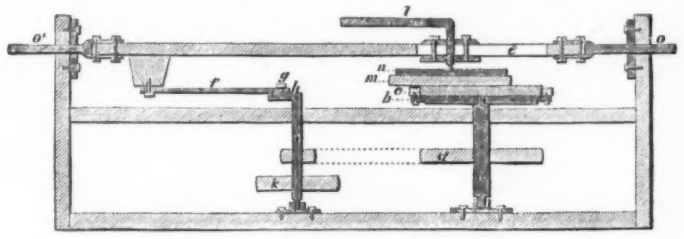


FIG. 21.—POLISHING MACHINE.

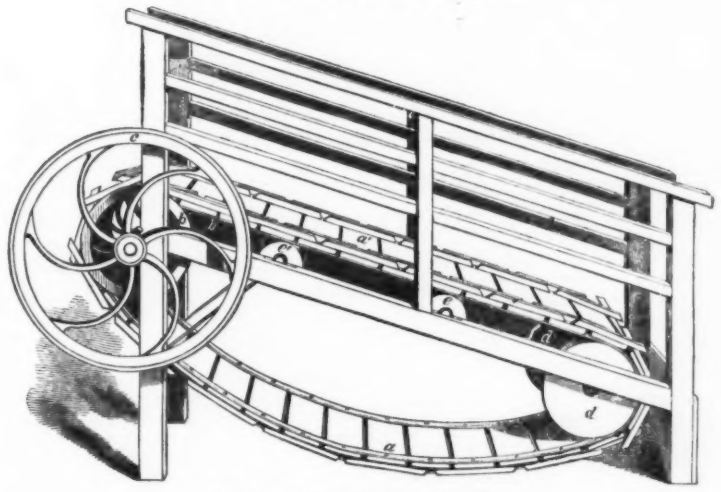


FIG. 22.—THE FOOT POWER.

the unsilvered surface would allow. A 6-inch aperture at the center, a ring an inch wide round the edge, and a 2-inch zone midway between the two.

e. Machines.

In the beginning of this section the difficulties into which I fell with Lord Rosse's machine were stated. These caused it at the time to be abandoned. A machine based on the same idea as Mr. Lassell's beautiful apparatus was next constructed. It varied, however, in this, that the hypocycloidal curve was described partly by the rotation of the mirror, and partly by the motions of the polisher—the axes of the spindles carrying the two being capable either of coincidence

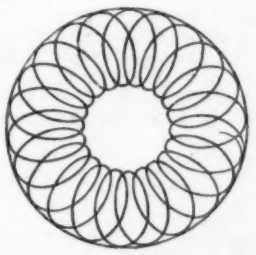


FIG. 26.—HYPOCYCLOIDAL CURVE.

or lateral separation to a moderate extent. A great deal of time and labor was expended in grinding and

* In order to examine Fig. 20, the book should be held with the left side of the page toward a window or lamp. The eye should also be at least two feet distant. The center will then be seen to protrude, and the surface present the apparent section engraved below it.

polishing numerous mirrors with it, but still the difficulty that had been so annoying in the former machine persisted. Frequently, in fact generally, from six to eight zones of unequal focal length were visible, although on some occasions when the mirror was hyperbolic, the number was reduced to two. At first it was supposed that the fault lay with the polishing, the pitch accumulating irregularly from being of improper softness, for it was found to be particularly prone to heap up at the center. But after I had introduced a method of fine grinding with elutriated hone powder, which enabled the glass to reflect light before the pitch polishing, it became evident that the zones were connected with the mode of motion of the mechanism. Many changes were made in the speed of its various elements, and a contrivance to control the irregular motion of the polisher introduced, but a really fine and uniform parabolic surface was never obtained, the very best showing, when finished, zones of different focal lengths. Although it cannot be said that I have tried this machine thoroughly, for Mr. Lassell has produced specula of exquisite defining power with it, and must have avoided these imperfections to a great extent, yet the evident necessity of complicating the movement* considerably, to avoid the polishing in rings, led me to adopt an entirely different construction, which was used until quite recently. Although it has now been replaced by another machine, which is still better in principle, and gives fine results much more quickly, yet as it produced one parabolic surface that bore a power of more than 1,000, and as it serves to introduce the process of grinding, it is worthy of description. The action of machines for grinding and polishing has been thoroughly examined in my workshop, no less than seven different ones having been made at various times.

The machine, which is a simplification of Lord Rosse's, was intended to give spiral strokes. It differed from the original, however, in demanding a changeable stroke, and in the absence of the lateral motion. In another most essential feature it varied from both that and Mr. Lassell's, *the mirror was always uppermost while polishing*, and being uncounterpoised escaped to as great an extent as possible from the effects of irregular pressure. To any one who has studied the deformations of a reflecting surface, and knows how troublesome it is to support a mirror properly, the advantage is apparent.

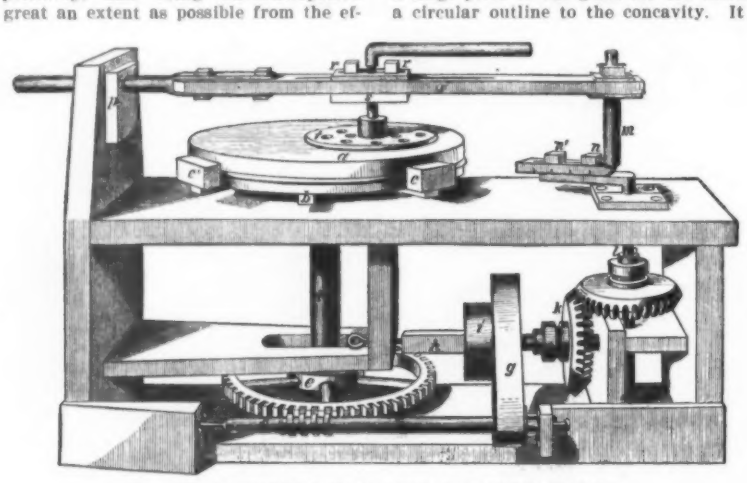


FIG. 25.—MACHINE FOR LOCAL CORRECTIONS.

The construction is as follows: A stout vertical shaft, *a*, Fig. 21, carries at its top a circular table *b*, upon which the polisher *c* is screwed. Below a band-wheel *d* is fixed. Above the table, at a distance of four inches, a horizontal bar *e* is arranged, so as to move back and forward in the direction of its length, and to carry with it by means of a screw *l*, the mirror, *m*, and its iron back or chuck *n*. The bar is moved by a connecting rod *f*, attached to it at one end, and at the other to a pin *g* moving a slot. This slot is in a crank *h*, carried by a vertical shaft *i*, near the former one, *a*. The band-wheel *k* is connected with the foot power, Fig. 22. The machine, except those parts liable to wear by friction, is made of wood. The ends, *o o'* of the horizontal bar *e*, are defended by brass tubes working in mahogany, and have even now but little shake, though many hundred thousands of reciprocations have been made.

The foot power consists of an endless band with wooden treads *a a'*, passing at one end of the apparatus over iron wheels *b b'*, which carry the band-wheel *c* upon their axle. At the other end it goes over the rollers *d d'*. Two pairs of intermediate wheels *e e'* serve to sustain the weight of the man or animal working in it. The treads are so arranged that they interlock, and form a platform, which will not yield downward. Owing to its inclination when a weight is put on the platform *a'*, it immediately moves from *b* toward *d* and the band-wheel turns. By a moderate exertion, equivalent to walking up a slight incline at a slow rate, a power more than sufficient to polish a 15½-inch mirror is obtained. This machine, in which very little force is lost in overcoming friction, is frequently employed for dairy use, and is moved commonly in the State of New York by a sheep. I have generally myself walked in the one used by me, and have traveled some days, during five hours, more than ten miles.

In order to give an idea of the method of using a grinding and polishing machine, the following extract from the workshop note book is introduced:

"A disk of plate glass 15½ inches in diameter, and 1¼ inch thick was procured. It had been polished flat on both sides, so that its internal constitution might be seen.* It was fastened upon the table *b* of the machine, by four blocks of wood as at *c*, Fig. 21. Underneath the glass were three thick folds of blanket, 15 inches in diameter, to prevent scratching of the lower face, and avoid risk of fracture. A convex disk of lead weighing 40 pounds having been cast, was laid upon the upper surface of the glass, and then the screw *l* was depressed so as to catch in a perforated iron plate *n*, at the back of the lead *m*, and press downward strongly.

"Emery as coarse as the head of a pin having been introduced, through a hole in the lead, motion was commenced and continued for half an hour, an occasional supply of emery being given. The machine made 150 eight-inch cross strokes, and the mirror 50 revolutions per minute. The grinder *m* was occasionally restrained from turning by the hand. At the end of the time the detritus was washed away and an examination with the gage made. A spot 11 inches in diameter, and 1-60 of an inch deep, was found to have been ground out. The same process was continued at intervals for ten hours, measurements with the gage being frequently made. The concave was then sufficiently deep. The leaden grinder was kept of the right convexity by beating it on the back when necessary. A finer variety of coarse emery, and after that flour emery were next put on, each for an hour. These left the surface moderately smooth, and nearly of the right focal length. The leaden grinder was then dismissed, and the iron one, Fig. 6, put in its stead. The mirror was removed from its place, and ground upon a large piece of flat glass for ten minutes, to produce a circular outline to the concavity. It was cemented with soft pitch to the concave iron disk, the counterpart of Fig. 6, and again recentered on the blanket table, *b*. Emeries of 3 and 20 seconds, and 1, 3, 10, 30, 60 minutes' elutriation were worked on it, an hour each. The rate of cross motion was reduced to 25 per minute to avoid heating, the mirror still revolving once for every three cross strokes. The screw pressure of *l* was stopped. This produced a surface exquisitely fine, semi-transparent, and appearing as if covered with a thin film of dried milk. It could reflect the light from objects outside the window until an incidence of 45 degrees was reached, and at night was found to be bright enough for a preliminary examination at the center of curvature.

"The polisher was constructed in the usual way, and being smeared with rouge was fastened to the table *b*, where the mirror had been. The latter, warmed in water to 120 deg. F., was then put face downward upon the former, and the screw *l* so lowered as to cause no pressure. The machine was allowed to make 20 four-inch cross strokes per minute, and the polisher to revolve once for every three strokes. The mirror being unconstrainedly supported on the polisher, was irregularly rotated by hand, or rather prevented from rotating with the polisher. The tendency of this method is to produce an almost spherical surface. To change it to a paraboloid, it was only necessary when the glass was polished all over to increase the length of the stroke to 8 inches, and continue working fifteen minutes at a time, examining in the intervals by the tests at the center of curvature. The production of a polish all over occupied about two hours, but the correction of figure took more time, on account of the frequent examinations, and the absolute necessity of allowing the mirror to come back to a state of equilibrium from which it had been disturbed when worked on the machine." I have seen a mirror which was parabolic when just off the machine, by cooling over night become spherical. And these heat changes are often succeeded by other slower molecular movements, which continue to modify a surface for many days after.

This correction, where time and not length of stroke is the governing agent, has once or twice been accomplished in fifteen minutes, but sometimes has cost several hours. If the figure should have become a hyperboloid of revolution, that is, have its edge zones too long in comparison with the center, it is only necessary to shorten the stroke to bring it back to the sphere, or even to overpass that and produce a surface in which at the center of curvature the edge zones have too short a focal length (Fig. 12).

Very much less trouble from zones of unequal focal length was experienced after this machine and system of working were adopted. This was owing, probably partly to the element of irregularity in the rotation of the mirror, and partly to the fact that the surface is kept spherical until polished, and is then rapidly changed to the paraboloid. Where the adjustments of an apparatus are made so as to attempt to keep a surface parabolic for some hours, there is a strong tendency for zones to appear, and of a width bearing a fixed relation to the stroke.

The method of producing reflecting surfaces, next to be spoken of, is however that which has finally been adopted as the best of all, being capable of forming mirrors which are as perfect as can be, and yet only requiring a short time. It is the correction of a surface by local retouches. In the account published by M. Foucault, it appears that he is in France the inventor of this improvement.

The mode of practising the retouches is as follows: Several disks of wood, as *a*, Fig. 23, varying from 8 inches to ½ an inch in diameter, are to be provided, and covered with pitch or rosin of the usual hardness, in squares as at *c*, on one side.* On the other a low cylindrical handle *b* is to be fixed. The mirror *a*, Fig. 24, having been fined with the succession of emeries before described, is laid face upward on several folds of blanket, arranged upon a circular table, screwed to an isolated post in the center of the apartment, which permits the operator to move completely round it. An ordinary barrel has generally supplied the place of the post, the head *c*, Fig. 24, serving for the circular table, and the rim *b* preventing the mirror sliding off. The other end is fastened to the floor by four cleats, *d d'*.

The large polisher is first moved over the surface in straight strokes upon every chord, and a moderate pressure is exerted. As soon as the mirror is at all brightened, perhaps in five minutes, the operation is to be suspended, and an examination at the center of curvature made. By carefully turning round, the best diameter for support is to be found, and marked with a rat-tail file on the edge, and then the curve of the mirror ascertained. If it is nearly spherical, as will be the case if the grinding has been conducted with care and irregular heating avoided, it is to be replaced on the blanketed support, and the previous action kept up until a fine polish, free from dots like stippling, is attained. This stage should occupy three or four hours. Another examination should reveal the same appearances as the preceding. It is next necessary to lengthen the radius of curvature of the edge zones, or what is much better shorten that of the center, so as to convert the section curve into a parabola. This is accomplished by straight strokes across every diameter of the face, at first with a 4-inch, then with a 6-inch, and finally with the 8-inch polisher. Examinations must, however, be made every five or ten minutes, to determine how much lateral departure from a direct diametrical stroke is necessary, to render the curve uniform out to the edge. Care must be taken always to warm the polisher, either in front of a fire or over a spirit lamp, before using it.

Perhaps the most striking feature in this operation is that the mirror presents continually a curve of revolution, and is not diversified with undulations like a ruffle. By walking steadily round the support on the top of which the mirror is placed, there seems to be no tendency for such irregularities to arise.

If the correction for spherical aberration should have proceeded too far, and the mirror become hyperbolic, the sphere can be recovered by working a succession of polishers of increasing size on the zone *a*, Fig. 16, intermediate between the center and edge, causing their centers to pass along every chord that can be described tangent to the zone.

A most perfect and rapid control can thus be exercised over a surface, and a uniform result very quickly attained. It becomes a pleasant and interesting occupation to produce a mirror. But two effects have presented themselves in this operation, which unfortunately bar the way to the very best results. In the first place the edge parts of such mirrors, for more than half an inch all around, bend backward and become of too great focal length, and the rays from these parts cannot be united with the rest forming the image. In the second place, the surface, when critically examined by the second test, is found to have a delicate wavy or fleecy appearance, not seen in machine polishing.† Although the variations from the true curve implied by these latter greatly exaggerated imperfections are exceedingly small, and do not prevent a thermometer bulb in the sunshine appearing like a disk surrounded by rings of interference, yet they must divert some undulations from their proper direction, or else they would not be visible. All kinds of strokes have been tried, straight, sweeping circular, hypocycloidal, etc., without effecting their removal. M. Foucault, who used a paper polisher, also encountered them. Eventually they were imputed to the unequal

* Messrs. De la Rue and Nasmyth, who used one of Mr. Lassell's machines, as I have since learned, met with the same trouble, and were led to make two additions to the mechanism: 1, to control the rotation of the polisher rigorously; and 2, to give the whole speculum a lateral motion, by which the intersecting points of the curves described by the polisher were regularly changed in distance from the center of the mirror. Mr. Lassell had previously, however, introduced a contrivance for this latter purpose himself.

* The glass that I have used has generally been such as was intended for dead-lights and sky-lights in ships.

* M. Foucault used plano-convex lenses of glass, of a radius of curvature slightly less than that of the mirror, and covered with paper on the convex face.

† By this it is not meant that there is a rippled polish, like that produced by buckskin.

pressure of the hand, and in consequence a machine to overcome the two above-mentioned faults of manual correction was constructed.

The mirror *a* is carried by an iron chuck or table *b*, covered with a tripie fold of blanket, and is prevented from slipping off by four cleats, *c c'*. The vertical shaft *d* passes through a worm-wheel *e*, the endless screw of which *f* is driven by a band *g* from the primary shaft *h*. At *i* is the band-wheel for connection to the foot-power. At one end of the primary shaft is firmly fixed the cogwheel *k*, which drives the crank-shaft *l*. Attached to the horizontal part of *l* is the crank-pin *m*. The two bolts *n n'* move in a slot, so that the crank-pin may be set at any distance from 0 to 2 inches, out of line with *l*. Above, the crank-pin carries one end of the bar *o*, the other end passing through an elliptical hole in the oak-block *p*. Down the middle of the bar runs a long slot, through which the screw-pin *q* passes, and which permits *q* to be brought over any zone from the center to the edge of the mirror *a*. It is retained by the bolts *r r'*, which are tapped into *s*. The local polisher is seen at *t*. The curve which the center of the local polisher describes upon the face of the mirror, varies with the adjustments. Fig. 26 is a reduction from one traced by the machine, the overlapping being seen on the left side. The mirror is not tightly confined by the cleats *c c'*, for that would certainly injure the figure, but performs a slow motion of rotation, so that in no two successive strokes are the same parts of the edge pressed against them.

The local polishers are made of lead, alloyed with a small proportion of antimony, and are 8, 6, and 4 inches in diameter, respectively. The largest and smallest are most used, the former on account of its size polishing most quickly, but the latter giving the truest surface. The rosin that covers them is just indentable by the thumb nail, and is arranged in a novel manner. The leaden basis, as seen at *t*, Fig. 25, is perforated in many places with holes, which permit evaporation, serve for the introduction of water where needed, and allow the rosin to spread freely. Grooves are made from one aperture to another, and the rosin thus divided into irregular portions. The effects of the production of heat are in this way avoided.

The mirror may be ground and fined on this machine, in the same manner as on that before described, or it may be ground with a small tool 8 inches in diameter, as recently suggested by M. Foucault, the results in the latter case being just as good a surface of revolution as in the former. It is best polished with the 8-inch, and a moderate pressure may be given by the screw *q*, if the pitch is not too soft. This, however, tends to leave an excavated place at the center of the mirror, the size depending on the stroke of the crank *m*, which should be about 2 inches. The pin *q* ought to be half way from the center to the edge of the mirror, but must be occasionally moved right or left an inch along the slot. When the surface is approaching a perfect polish, the warmed 4-inch polisher must be put in the place of the 8-inch. The pin *q* must be set exactly half-way between the center and edge of the mirror, and the crank must have a stroke of two inches radius. The polisher then just goes up to the center of the glass surface with one edge, and to the periphery with the other, while the outer excursion of the inner edge and inner excursion of the outer edge meet, and neutralize one another at a midway point. Wherever the edge of a polisher changes direction many times in succession, on a surface, a zone is sure to form, unless avoided in this manner. All the foregoing description is for a 15½-inch mirror.

By this system of local polishing the difficulties of heat, distribution of polishing powders, irregular contact of the rosin, etc., that render the attainment of a fine figure so uncertain usually, entirely disappear. A spherical surface is produced as above described, and afterward by moving *q* toward the edge, and at the same time increasing the stroke, it is converted into a paraboloid. The fleecy appearance spoken of previously is not perceived, and the surface is good almost up to the extreme edge.

(4) *Eye-Pieces, Plane Mirrors and Test Objects.*

The telescope is furnished with several eye-pieces of various construction, giving magnifying powers from 75 to 1,200, or if it were desired even higher. For the medium powers 300 and 600 Ramsden, or rather positive eye-pieces have been adopted. They differ, however, from the usual form in being achromatic, that is, each plano-convex is composed of a flint and crown, arranged according to formulas calculated by Littrow. In this way a large flat field and absence of color are secured, and the fine images yielded by the mirror are not injured. For the higher powers, single achromatic lenses are used, and for the highest of all a Ross microscope.

With these means it has been found that the parabolic surfaces yielded by the processes before described, will define test objects excellently. Of close double stars they will separate such as γ^2 Andromedæ, and show the colors of the components. In the case of unequal stars which seem to be more severe tests, they can show the close companion of Sirius—discovered by Mr. Alvan Clark's magnificent refractor—the sixth component of θ^1 Orionis, and a multitude of other difficult objects.

As an example of light-collecting power, Debillisima between ϵ and 5 Lyræ is found to be quintuple, as first noticed by Mr. Lassell. In the 18½-inch specula of Herschel, it was only recorded as double, and, according to Admiral Smyth, Lord Rosse did not notice the fourth and fifth components. Jupiter's moons show with beautiful disks, and their difference in diameter is very marked. As for the body of that planet, it is literally covered with belts up to the poles. The bright and dark spots on Venus, and the fading illumination of her inner edge and its irregularities are perceived even when the air is far from tranquil. Stars are often seen as disks, and without any wings or tails, unless indeed the mirror should be wrongly placed, so that the best diameter for support is not in the perpendicular plane, passing through the axis of the tube.

It has been found that no advantage other than the decrease of atmospheric influence on the image results from cutting down the aperture of these mirrors by diaphragms, while the disadvantage of reducing the separating power is perceived at the same time. Faint objects can be better seen with the whole surface than with a reduced aperture, and this though apparently a property common to all reflectors and object glasses is not so in reality. A defective edge will often cause the whole field to be filled with a pale milky light, which will extinguish the fainter stars. Good definition is just as important for faint as for close objects.

The properties of these mirrors have been best shown by the excellence of the photographs taken with them. Although these are not as sharp as the image seen in the telescope, yet it must not be supposed that an imperfect mirror will give just as good pictures. A photograph which is magnified to 3 feet, represents a power of 380. As the original negative taken at the focus of the mirror is not quite 1½ inches in diameter when the moon is at its mean distance, it has to be enlarged about 25 times, and has therefore to be very sharp to bear it.

The light-collecting power of an unsilvered mirror is quite surprising. With a 15½-inch, the companion of *a* Lyræ can be perceived, though it is only of the eleventh magnitude. The moon and other bright objects are seen with a purity highly pleasing to the eye, some parts being even more visible than after silvering.

In order to finish this description, one part more of the optical apparatus requires to be noticed—the plane mirrors. In the Newtonian reflector the image is rejected out at the side of the tube by a flat surface placed at 45 deg. with the optical axis of the large concave.* If this secondary mirror is either convex or concave, it modifies the image injuriously, causing a star to look like a cross, and this though the curvature be so slight as hardly to be perceptible by ordinary means. For a long time I used a piece 3 x 5 inches, which was cut from the center of a large looking glass accidentally broken, but eventually found that by grinding three pieces 6 inches in diameter against one another, and polishing them on very hard pitch, a nearer approach to a true plane could be made. They were tested by being put in the telescope, and observing whether the focus was lengthened or shortened, and also by trial on a star. When sufficiently good to bear these tests, a piece of the right size was cut out with a diamond, from the central parts.

(To be continued.)

TRADE NOTES AND RECIPES.

Kremnite a New Building Material.—Clay, sand, and fluor-spar are mixed in a finely-divided state, and melted at a high temperature. The liquid mass obtained can be cast like iron, and blocks as well as castings may be produced. The material can be colored in black to pale or bright shades; it may be polished or ground, takes glaze well, and is well adapted for the production and imitation of colored marble and other natural stone. Large pieces of any desired shape have been successfully cast from it. Kremnite is suited for building uses, for architectural and artistic purposes. Hollow bricks for buildings and stoves, fancy bricks having the appearance of marble, tiles for floors and sidewalks, can be produced with this material, and success has also been achieved in manufacturing corrugated thin plates for roofs. Kremnite is made in a factory near St. Petersburg.—Chemiker Zeitung.

Impregnated Dust Cloths.—The ordinary cloths for wiping off dust present the disadvantage of not absorbing or taking up the dust on furniture, floors, etc. They only whirl it up, the consequence being that a piece of furniture from which the dust has been wiped with such a cloth, will be covered again with dust after a few minutes, the flying dust falling back into its old place. In order to avoid this, the dust is removed with damp cloths, but this cannot be done in every case without damaging the object, such as polished articles, etc.

The impregnating liquid for dust cloths described below obviates all these drawbacks, since the cloths thus treated take up all dust entirely, possessing, besides, the advantage that they can be used for months with uniform success, without requiring cleaning.

The liquid is produced by mixing 30 kilos of the best American kerosene with 10 kilos of double-refined rapeseed oil, heating this moderately and stirring into it 1 kilo benzoin (*Benzoe amygdaloides*) previously liquefied by melting.

In this liquid the cloths are immersed so as to become entirely saturated with the liquid; next they are taken out, wrung out well, and dried in a shady place. When they are dry, the cloths are ready for use. They do not injure even polished furniture, but rather impart to it an increased brilliancy.—Der Chemisch-Technische Fabrikant.

* A right-angled prism cannot be used with advantage to replace the plane silvered mirrors, because it transmits less light than they reflect, is more liable to injure the image, and the glass is apt to be more or less colored. Its great size and cost, one three inches square on two faces being required for my purposes, have also to be considered.

ELECTRICAL NOTES.

Owing to the complete success that has attended the working of wireless telegraphy between the Goodwin Sands and the shore, the British Board of Trade and Trinity House have concluded a contract with Marconi's Wireless Telegraph Company for the equipment of lightships around the coasts with Marconi installations. Lightships will thus be able freely to communicate with the shore and with one another for all purposes of the service.

The electrical furnace may be defined as a structure to which electrical energy is delivered for its conversion into thermal energy. Accepting this definition, the date of its invention goes back to the time when it was discovered that electricity passing through a conducting medium is converted into heat. It is, therefore, over a century old. Comparatively little attention was devoted to it, however, until twenty-five years ago, when Sir William Siemens devised and exhibited in operation his furnaces for the melting of platinum, iron, and other metals. So important an epoch did his work mark that Siemens is with justice called the father of the electric-furnace industry. The usefulness which he ascribed to the electric furnace and the possibilities which he pointed out have been more than realized. Since then results of the greatest importance have been attained. Many of nature's most closely-guarded secrets have been revealed; a new chemistry of high temperatures has been evolved; new ideas as to the constitution of matter have been developed; new methods of preparing known substances have been formulated; our stores of available materials have been enriched by the discovery of new compounds. Such are the results which have been accomplished through scientific research.

It is a well-known fact that the energy loss in the core of an armature or of a transformer is due to magnetic hysteresis and to eddy or Foucault currents, the eddy current loss being directly proportionate to the electric conductivity of the steel. It is well known, too, that, generally speaking, when the hysteresis loss is small, the material being "soft," the electric conductivity is considerable, and *vice versa*. It is, of course, desirable that both of them should be small at the same time. It is, moreover, a desideratum that the permeability should be good. For cast steel and steel plates used in pole-pieces, high magnetic induction values and good permeability, as regards common saturation, are most important factors, while, on the other hand, the magnetism not being reversed, the hysteresis properties of the material are of less account. Yet the electric conductivity of the pole material is of interest as regards the eddy currents produced by the variations in magnetism from the slotted armatures generally used. Some interesting facts concerning these questions have lately been established by the distinguished investigators, Barrett, Brown, and Hadfield, in their researches on a large number of alloys of steel. These gentlemen have shown that the addition of silicon or aluminium has considerable influence on the above-named magnetic and electric properties. In this report further researches upon these phenomena have been described, and in addition to a number of specimens of Swedish commercial iron and steel, some samples of specially prepared composition have been tested similar to those just mentioned. The researches have been carried out at the Testing Institution of the Royal Technical University of Stockholm.

In the old and densely populated European countries, the commercial conditions affecting printing telegraphs are different from the conditions prevaling in this country. In countries like England, France, and Germany, the bulk of the telegraph traffic is confined within each country, the maximum distances instead of 2,000 or 3,000 miles are not more than about 500 miles, and the population instead of being scattered is very dense. These are ideal conditions for the use of the telephone, and the telephone service in Europe has grown immensely during the last few years. The telegraph service has suffered correspondingly. For several years past the number of telegrams transmitted per annum in European countries has been either decreasing or stationary or increasing very slowly. Even in America telephone competition has had a marked effect on telegraph traffic. But in America the great distances and the rapid growth of population still make the increase of the carrying capacity of the wire, that is to say the saving of telegraph wires, an important commercial factor. In Europe, on the other hand, the printing telegraph inventor soon finds that the telegraph administrations are indifferent about line saving. They have as many, in fact, in some cases, more, wires than they require at present, and their one insistent demand is for a printing telegraph system that will save labor. This is particularly the case in England, where considerations of public policy have compelled the laying of underground cables, thereby increasing the superfluity of telegraph wires. The French post office more than twenty-five years ago took up the Baudot system and developed it until it was capable of transmitting six messages simultaneously over one wire 550 miles long from Paris to Marseilles. The result has been a saving of expenditure on telegraph wires many times outweighing the expenditure on the Baudot system. It is true that in English-speaking countries the Morse quadruplex has effected a similar saving, but not to anything like the same extent. The Baudot system, however, does not save labor to any noticeable amount, and some very interesting attempts have been made recently to convert it to a labor-saving as well as a line-saving system.

SCIENCE NOTES.

In general, the problems in plant physiology have been well brought out and systematized through the monumental work recently completed by Prof. Pfeffer. To him the science owes a debt of gratitude which may be acknowledged as well by one who attempts to suggest future work as by the historian. Again, due recognition should be made of those who have in recent years based upon this or any similar topic valedictory addresses before various botanical organizations—notably, those of Profs. Vines, Ward, Barnes, Reynolds, Green, and others.

There is certainly much in physiology which must be based upon physics and chemistry, but when dealing with the causes of the activities of living organisms, it is in relatively few cases that explanations may ever be offered in terms of physics and chemistry alone. Nor is it possible to offer such explanations without the assistance of these sciences. The progress of the work in physiology is indissolubly bound up in the development of other sciences. The benefits are, however, mutual, and as physiology acknowledges the fundamental importance of these related sciences, they in turn must acknowledge the important contributions, often of fundamental nature, which have resulted through physiological investigation.

The species of weevils which infest chestnuts are two in number—the larger chestnut weevil, *Balaninus proboscideus* Fab., and the lesser chestnut weevil, *B. rectus* Say. They have extremely long, slender beaks or snouts, nearly as fine as a horsehair, and considerably longer than the body in the female. By means of this long beak the female is able to penetrate the thickest burr of the chestnut with its long spines and to cut out, with the minute and sharp mandibles at the tip of her beak, a little hole for the deposition of her eggs. These are inserted through the husk into the growing nut. The two species resemble each other greatly in color and in markings, the general color of both being golden yellow, ochraceous or clay yellow, frequently tinged with olive, and a little paler on the lower surface. The disk of the thorax is a little darker, with a wide bright band on each side, and the elytra, or wing-covers, are mottled with rich light brown or dark brown markings of variable size and extent.

The first work on agriculture published in England was the "Book of Husbandry," by Sir Anthony Fitzherbert, in 1534. This was followed by another from the same author in 1539. Thomas Tusser's "Five Hundred Points in Good Husbandry" followed a quarter of a century later, and went through many editions, one so late as 1812. Then followed "The Whole Art of Husbandry," by Barnaby Googe, and the "Jewel House of Art and Nature," by Sir Hugh Platte, in 1652. At the same time appeared the first work on foreign husbandry, relating to Brabant and Flanders, by Sir Richard Weston. Indian corn, potatoes, squashes, carrots, artichokes, cabbages, and turnips were all unknown in England until about the middle of the sixteenth century. The peasants subsisted chiefly upon barley bread, ground in hand-mills, and baked by themselves. Flax was first grown in England in 1533, the vine was reintroduced in 1552 and many of the fruits and flowers now in common use were brought from Persia into Constantinople and thence into Europe, during the period 1570 to 1640. Orange trees were first planted in northern Europe, 1548; turkeys and guinea fowls were introduced into France in 1570.

The popular red, formerly known as Adrianople red, but now commonly as Turkey red, famous for the permanency, intensity, and beauty of its color, owes its quality of exceptional fastness to castor oil. The coloring matter itself, alizarine, which was originally derived from the root of the madder plant, but is now almost wholly supplanted by an artificial dyestuff of the same name obtained from anthracene, a product of the distillation of coal tar, has, like many dyes, little affinity for cotton fiber. Applied directly to the cloth by ordinary methods it gives a color of little permanency. To fix this color there is necessary the treatment of the cloth with some substance or agent which, having an affinity for both the cotton tissue and the coloring matter, alizarine, assists in effecting a chemical combination between them. The substance now almost exclusively used for this purpose is castor oil. Mixed with a small quantity of concentrated acid, which is then washed away by a solution of common salt, and soda or ammonia being added to saponify the fatty acids, there is produced from castor oil another oil which is perfectly soluble in water, a property especially desirable for the saturation of cotton cloth. The resultant oil is known by many names—sulphureted castor oil, soluble oil, sulforicinate, etc.—but from the use to which it is largely devoted, that of fixing alizarine dye upon cotton goods, it is generally known as alizarine-assistant, or Turkey-red oil. The economic value of this oil depends largely upon the fact that the specific red thus fixed by it upon cotton cloth is one of the most permanent colors known to the dyer's art. Soluble oil is also used as a substitute for the more expensive glycerin in the treatment of cotton cloth. It has an admirable effect upon starch mixtures, and imparts to the fabric a quality of softness, suppleness, and pliancy. Although no definite figures are extant as to the quantity of castor oil annually consumed by the textile industry, the consensus of opinion among those best qualified to know is that a greater portion of the castor-oil output of the United States is utilized in the treatment of cotton goods than for any other single purpose.

JUST PUBLISHED

American Tool Making and Interchangeable Manufacturing

By JOSEPH V. WOODWORTH

THIS book is a complete practical treatise on the Art of American Tool Making and System of Interchangeable Manufacturing as carried on to-day in the United States. In it are described and illustrated all of the different types and classes of small Tools, Fixtures, Devices and Special Appliances which are, or should be, in general use in all machine manufacturing and metal working establishments where economy, capacity and interchangeability in the production of machined metal parts are imperative.

All of the tools, fixtures and devices illustrated and described have been, or are, used for the actual production of work, such as parts of Drill Presses, Lathes, Patented Machinery, Typewriters, Electrical Apparatus, Mechanical Appliances, Brass Goods, Composition Parts, Mould Products, Sheet Metal Articles, Drop Forging, Jewelry, Watches, Metals, Coins, etc.

The treatment of each tool described and illustrated is such as to enable any Practical Man to Design, Construct and Use Special Tools, Dies and Fixtures, for the Rapid and Accurate Production of Metal Parts Interchangeably.

To the Machinist, Tool Maker, Designer, Die Maker, Superintendent, Manager and Shop Proprietor this book shows the 20th Century Manufacturing Methods and Assists in Reducing the Expense and Increasing the Output and the Income. A book on the System of Interchangeable Manufacturing—The System that has Won for the United States the Industrial Supremacy of the World.

535 Pages Bound in Cloth 600 Illustrations

PRICE $4.00

MUNN & CO., Publishers
SCIENTIFIC AMERICAN OFFICE
361 BROADWAY - - NEW YORK

TWENTY-THIRD EDITION

EXPERIMENTAL SCIENCE

By GEORGE M. HOPKINS

Revised and Greatly Enlarged. 2 Octavo Volumes. 1,100 Pages. 900 Illustrations. Cloth Bound, Postpaid, $5.00. Half Morocco, Postpaid, $7.00. Or Volumes Sold Separately: Cloth, $3.00 per Volume. Half Morocco, $4.00 per Volume.

EXPERIMENTAL SCIENCE is so well known to many of our readers that it is hardly necessary now to give a description of this work. Mr. Hopkins decided some months ago that it would be necessary to prepare a new edition of this work in order that the many wonderful discoveries of modern times might be fully described in its pages. Since the last edition was published, wonderful developments in wireless telegraphy, for example, have been made. It was necessary therefore that a good deal of new matter should be added to the work in order to make it thoroughly up-to date, and with this object in view some 200 pages have been added. On account of the increased size of the work, it has been necessary to divide it into two volumes handsomely bound in buckram.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. AUTOMOBILES.—English Motor Omnibuses for City and Country Use.—8 illustrations 24740

II. CHEMISTRY.—Precious Metals Discovered by Cyanide Processes.—By CHARLES E. MUNROE, Ph.D. 24738

III. ELECTRICITY.—Electrical Notes 24747
Electrotyping.—By Dr. F. MOLLWO PERKIN 24735
The Cerebotani Autotelegraph.—4 illustrations 24736

IV. MISCELLANEOUS.—Consumption of Horseflesh in Germany 24743
Ether Drift 24743
Science Notes 24748
Trade Notes and Recipes 24747

V. NATURAL HISTORY.—Curious Habits of Wasps 24743

VI. OPTICS.—The Construction of a Silvered Glass Telescope Fifteen and a Half Inches in Aperture, and its Use in Celestial Photography.—II.—By HENRY DRAPER, M.D.—19 illustrations. 24744

VII. RAILWAY ENGINEERING.—Comparative Tests of Steam and Electric Locomotives 24734

VIII. STEAM ENGINEERING.—Test of a Steam Turbine After Two Years' Service 24742
The Zoelly Steam Turbine.—By FRANK C. PERKINS.—4 illustrations 24737

IX. TECHNOLOGY.—Proper Methods in Conducting Painting Tests 24734

Home Mechanics for Amateurs

This book has achieved an unparalleled success in one week, and a Special Edition of 4,000 copies has been ordered. It is by far the largest and best book on the subject ever offered at such a low price. It tells how to make things the right way—the "only" way—at small expense It will prove of value to you—much more than you realize. Do things with your hands. Send for a circular giving contents—the circulars cost only a cent—the book $1.50 postpaid. If the book could meet you face to face you would be the first to purchase. The first large edition is almost gone. Order to-day.

370 Pages 326 Engravings Price $1.50

LATEST EDITION
.... OF ...
Supplement Catalogue
JUST OUT!

Write for it. It costs nothing.

The new Catalogue contains 65 pages and gives a list of over 17,000 articles.

If there is any scientific, mechanical or engineering subject on which you wish special information, you will find in this Catalogue some papers in which it is thoroughly discussed by a competent authority.

SCIENTIFIC AMERICAN SUPPLEMENT papers for the most part have been written by the world's most eminent engineers and scientists. They contain information that is not always accessible in books.

MUNN & COMPANY, PUBLISHERS
361 BROADWAY NEW YORK CITY